PLANT PROTECTION
IN
ORNAMENTAL CROPS

By

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Back Page Cover: (1) Botrytis blight symptoms on gladiolus leaves (2) Botrytis blight on gladiolus plants
FOREWORD

Flowers have been grown in India since time immemorial and form an integral part of our rich heritage and culture. We have a long tradition in floriculture and our association with flowers in day to day life is inseparable. Flowers have been depicted in ancient scriptures, paintings, description of Gods and Godesses, and various social customs. However, the economic aspects of flower cultivation has been recognised only later. It is only in the last two decades with changing life styles and rapid urbanisation, floriculture has assumed a definite commercial status in India. Its potential as a viable agribusiness has been recognised in the form of large number of floriculture units with the export base. It is needless to mention here that the flower crops provide higher income from comparatively smaller areas with higher profitability than other crops. Besides earning foreign exchange and improving the national income, the floriculture business being labour intensive, generates gainful employment of young entrepreneurs in peri-urban, sub-urban and rural areas.

It is now well known that floriculture is a lucrative industry in many parts of the world. India has yet to cash in on the production, marketing and export potentials in this field. There is a huge untapped flower production potential in our country, which could benefit large population in the weaker section. Both domestic market and export potential are tremendous. In India to-day, floriculture is being viewed as a high growth industry. The components of floriculture industry in the country are production of loose-flowers, cut-flowers, potted plants; flower seeds, bulbs and other propagative materials; ornamental plants for interior decoration and landscape use, dry flowers and dry plant parts as well as essential floral oils and pigments. This increasing trend and diversified avenues have generated the need for new technologies for greater commercialization and professionalism in the management of production and marketing.
For successful ornamental crop production both for domestic and export markets, there should be strong technological base to solve the day-to-day problems. One of the major advances required for quality crop production is in the area of disease and pest management and availability of suitable agrochemicals. This is the area with its weak indigenous technology created difficulties in successful production. Timely diagnosis of pests and their management should become an important part of the ornamental crop production. With the increasing hazards of pesticide and fungicide usage various components of integrated pest management (IPM) and integrated disease management (IDM) should be the integral part of the crop production. There is imperative growing need for knowledge on different aspects of disease and insect pest diagnosis and management. Hence the decision by the AICRP on Floriculture (ICAR) in bringing out a publication on "Plant Protection in Ornamental Crops" based on the work done in important ornamental crops is a welcome step which will serve very useful purpose for the flower growers. I congratulate Dr. S.K. Bhattacharjee, Project Coordinator, AICRP on Floriculture (ICAR), New Delhi who is instrumental in bringing out this invaluable publication which was long overdue. The efforts of the authors Dr. Pratibha Sharma and Dr. S.K. Bhattacharjee are indeed praise-worthy in this respect. I am sure this publication will be of immense value and serve the interests of scientists, students, policy makers, amateurs and commercial flower growers.

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(PANJAB SINGH)
PREFACE

With the adoption of improved production technologies, a number of diseases and pests, affecting ornamental crops are becoming a serious handicap in their economic production. Most of these pests adversely affect the vigour and growth of the plants, deteriorating yield structure, quality of flowers, decorative value of foliage, seed yield and quality and survival value of the plants. A number of diseases are carried through soil and attack different host plants because of their wide host range. As the seeds of various ornamental plants are produced by different nurserymen, who generally use the same land year after year for growing flowering crops, the pathogens present in the soil keep on multiplying and attack the plants. Many of the seedlings raised carry infection, which develops further after transplanting, causing their mortality or the infection develops on the growing plants producing various types of symptoms. Growers hardly adopt any control measures because of their ignorance about the symptomatology and lack of information on management practices. Pest problems also develop in greenhouse conditions. An attempt has been made in this bulletin to compile the major diseases occurring on the important ornamental crops along with the symptoms and management practices. The recommended and general management practices have been explained for soil, seed and air borne diseases caused by fungi, bacteria and viruses, so that an integrated approach for the protection technology may be undertaken. Major insects and nematodes have also been dealt cropwise. Chapters on diagnosis of symptoms of damages caused by the diseases, insects and nematodes have been written with the aim to introduce the growth of the pest and its nature of damage. Pesticides play a vital role in minimising the crop losses and increasing the flower yield. However, increasing awareness about the safe and judicious use of pesticides by the flower farmers requires enormous extra efforts. Indiscriminate application of pesticides has lead to pest resistance and resurgence as well as adverse effect on the ornamental crops and also on flora and fauna in the ecosystem. There should be need based use of pesticides as a component of integrated pests and disease management. Hence, a chapter has been devoted in this publication on this important aspect; information on microbial biofungicides and biocontrol agents are also furnished. The major components of integrated pest management viz., a cultural, biological and chemical method includes the general recommendations being utilized for crop protection. Tips for integrated management of very common pests have been described. Generally recommended pesticides along with the cultural practices of major crops used for cut flowers, loose flowers, aquatic ornamentals and foliage plants have been dealt with in this publication. Efforts have also been made to compile the useful information so as to make the pest management an easy process.
The authors express their gratitude to Dr. Panjab Singh, Director General, Indian Council of Agricultural Research and Secretary, Department of Agricultural Research and Education for his active inspiring guidance, support and encouragement in bringing out this publication. The authors are also grateful to Dr. G. Kalloo, Deputy Director General (Horticulture) for his help in this technical bulletin. The authors are thankful to the scientists of different coordinating centres who conducted their experiments in scientific spirit and generated very useful information. It is hoped that this bulletin will serve as a useful reference manual to the plant protection scientists, extension workers, students, teachers and flower growers.

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INTRODUCTION

As a part of the All India Coordinated Floriculture Improvement Programme, ICAR, this plant protection bulletin is designed as a collection of information, which can be used by field workers as a handbook for identification of crop diseases and pests. It incorporates diseases, insects and nematodes problem of important ornamental crops used as cut plants, loose flowers, foliage plants. As such it will be useful to students who are general floriculturists, as well as to specialists in crop protection. Efforts have been made to provide information on diseases and pests of major commercial ornamental crops.

The agricultural significance of diseases pests in flower crops is that the damage caused by them adversely affects the vigour and growth of the plants, thereby reducing the quantity or quality of yield. Often the first evidence of the presence of a pest or disease is the appearance of the crop, which may exhibit particular types of pest damage or disease symptoms. Nevertheless, particularly with insect pests, the pest itself may be seen before crop damage has actually occurred. Therefore, searching crop for the presence of pest organisms before any obvious damage has been done is important for predicting the likely occurrence of pest damage.

Flowers, being the perishable commodity their shortage can not be met only by imports. There is a need for increasing the production and availability from the existing area under these crops and ensuring that the produce remains unspoiled before it reaches the consumer. Pests (pathogen and insects) play the major role in spoiling the standing crop from the seedling stage till harvest and spoilage caused by micro organism during transit, storage and marketing are the major constraints in increased production and availability.

The aim of this plant protection bulletin is to allow a preliminary identification of the most important diseases, insects and nematodes of major crops of national and international importance based primarily on their major characteristics or symptoms. An attempt has been made to provide information on methods of pest management schedules. Diseases are generally recognized and named accordingly to their symptoms and the common English names have been used. Many disease names sometimes incorporate the generic name of the causal organism (pathogen). Often more than one pathogen may be responsible for a particular disease symptom, so examining the symptoms and identifying the pathogen can only help in understanding the disease. This usually demands some laboratory procedure to examine the pathogen by physical methods and culturing, followed by microscopic examination and biochemical, serological or other tests (especially for bacteria and viruses).

The common names used in the text for insects and nematodes are generally used internationally, since sometimes it is very confusing as countries have their own local names also mainly it happens in insects. An attempt has been made to compile information for disease, insects and nematodes recorded in India and general problems reported elsewhere has also been included. Mention is also made of the more effective and economic control measures of the important pests with an integrated approach.

In the section of plant diseases, a choice of methods or combination of methods is made available. Crop cultivars with resistance to particular diseases are often used, but reliability and availability of particular cultivars vary from place to place. Indian cultivars on this particular
aspect have been incorporated. Relevant cultural methods are also included. Where disease pressure is severe, however, chemical methods may have to be used in support. Generally recommendations made for fungicides their approximate rates of use and timing of application are given.

For management of each major insect and nematodes generally recommended pesticides have been mentioned. Somewhere, descriptions on available cultural methods have also been made. The intention is to indicate which types of pesticides are recommended and which specific compounds have been found to be effective against each pest or a close relative. Pesticide recommendations vary considerably from crop to crop, place to place and season to season. Doses depend on active ingredient. Most of the pesticides like DDT, Dieldrin, HCH and other organomercurial compounds are either banned or else are very restricted in use. Care has been taken to provide information on the effective pesticide. The question of desirability of use on grounds of pollution hazards or other ethical considerations and success of management practices depends on individual users, severity of the problem, economic threshold and promptness of the management schedules.

### PART I

**DIAGNOSIS OF DISEASES AND INSECT PESTS**  
(fungi, bacteria, viruses, insect and nematodes)

Diagnosis of the problem is the pre-requisite of planning a pest management schedule. Before going into the details of the management it is necessary to understand pest and nature of its damage.

**What is a Pest?**

A pest is any organism, animal, plant or microorganism that causes damage or annoyance to human beings, their animals, crops or possessions. The word pest is derived from the Greek word ‘pestis’ which means to annoy.

The major pests of agricultural importance can be broadly divided in to the following groups:

- **Plant Pathogens:** Fungi and various microorganisms such as bacteria and viruses cause diseases in plants. Nematodes are also sometimes classified as pathogens.
- **Insect and Mite Pests:** Insect pest and mites cause heavy damage to crops. Out of the over one million species of insects only about 200 species can be described as serious pests. A large majority of insects are beneficial to mankind.
- **Weeds:** These are plants that either compete with crop plants thus affecting yield and quality, or may interfere with the use of land and water resources.
- **Vertebrate Pests:** These are mainly rodents, birds and some other mammals that cause damage to crops and stored products.

The particular types of damage or disease symptoms are often characteristic of particular disease organisms, insects, or nematodes (either of individual or at least of taxonomically related
groups of organisms). It is therefore important for a field worker to be able to recognize when a crop is damaged or diseased and to know the likely cause. This requires an adequate practical knowledge of the crop, agricultural operations, production techniques and plant protection. Knowledge of the use of nutritional and cultural requirements and its basic botanical and physical features is also important. A practically experienced worker will recognize the unhealthy crop and also understand the symptoms.

In practice, the recognition of a pest or pathogenic organism solely from the type of damage or symptoms caused can be rather complicated. Plants attacked by disease organisms (bacteria, fungi, viruses) will show a range of symptoms, some of which are similar to those produced by insect attack. Similarly, various mineral deficiencies (manganese, potassium, etc.) result in symptoms such as foliage mottling which is similar to some virus diseases. Drought, hail, frost, rain, lightning and sun-scorch, can all produce physical damage to plants; as can excessive doses of fertilizer, various pesticides, herbicides, and some spray additives. In addition, there may be damage by myriapods, molluscs (slugs and snails), nematodes (eelworms), birds and mammals. Damage of this sort can be confused with different types of insect and mite damage. Thus the identification of the cause of physical damage or distortion to the plant body may be a matter of some difficulty to the inexperienced crop protection worker.

Nevertheless, it is vitally important that the causal organism be correctly identified in order that the economic significance of the disease or pest infestation can be correctly assessed and that appropriate control measure can be applied. It is the causal agent, whether pest or pathogen, at which controls measures are aimed. In the case of pathogens particularly, several factors may interact to cause disease in crops: insects spread virus diseases or create wounds through which pathogens may infect the plant; crop damage caused by rain, wind, hail or mechanical damage from man-made implements may also allow infection through wounds; unfavourable soil conditions such as drought, waterlogging, salinity or nutrient imbalances may make plants susceptible to soil borne pathogens. Several pests and pathogens are often found attacking the same crop simultaneously. Each one may augment the damage caused by the others, thus confusing the overall symptom picture. Therefore, when assessing health of a crop in the field, adequate attention should be paid to the additive or modifying effects of local agricultural and environmental factors; and to the possible interacting effects of the various pests and pathogens which may be found.

A) SYMPTOMS OF DAMAGE BY PATHOGENS

There are two steps involved in the accurate identification of plant diseases. The first is the recognition of the diseased plant in the field and the identification of disease according to the observed symptoms. The second is the accurate identification of the pathogen causing the disease. It is important to remember that several (often-dissimilar) pathogens and some non-pathogenic factors may cause diseases with similar symptoms. Accurate identification of the pathogen is therefore essential. Since most pathogens cannot usually be identified in the field, it is usually necessary to send specimens to a plant pathology laboratory for culturing and microscopic examination. The symptoms, however, can be recorded in the field: symptoms, prevalence and other circumstances referred to under ‘Preliminary examination and collection of disease plants’.
Plant diseases can only be adequately recognized and described if the correct terms are used for the different types of symptoms. Specimens sent to a laboratory should always be accompanied by full description of the symptoms as they appeared in the field. The part of the plant showing the symptoms, whether the symptoms are generalized (systemic) or localized and the appearance of lesions (colour, texture, shape, size) are the characters most often used to describe disease symptoms. A list of the most common types is shown here.

**Plant Disease Symptoms**

**Systemic** (Affects all or most of the plant)

**Chlorosis**: Yellowing is frequently seen in plants with root or vascular diseases but may also be due to nutrient deficiencies (actual or induced). Nitrogen deficiency causes yellowing of mature leaves, while iron deficiency causes yellowing of the youngest leaves. Specific chlorotic patterns (mosaics, streaks, and ‘oak leaf’ patterns) may indicate a virus disease.

**Etiolation**: extended growth, typically due to excessive shading, but some pathogens can cause this symptom.

**Stunting or dwarfing**: can be caused by some viruses or bacteria cause such problems. General nutrient deficiencies or root disease can also reduce growth and cause stunting.

**Wilting**: can be caused by diseases interfering with the water-conducting processes of the plant. The xylem vessels may become blocked or toxins produced by the disease organism may affect surrounding tissue.

**Growth distortion**: abnormal stem and leaf shapes or peculiar arrangements of leaves and stems can be caused by viruses. Herbicide damage can also be responsible.

**Localized**

Individual lesions that are restricted to certain plant parts may, nevertheless, occur over large areas. Some more common types of lesion are:

**Anthracnose**: Dark, sunken, necrotic spots or patches, sometimes with raised borders, usually on leaves or fruit. Although most frequently caused by fungal pathogens belonging to the genus *Colletotrichum*, similar fungi and some bacteria may cause these symptoms.

**Blight**: a rather loose term used to describe sudden and fairly extensive shriveling and death of certain areas of the plant. It can be caused by a wide range of fungal and bacterial pathogens.

**Cankers**: Localized areas of diseased tissue producing open sunken wound, often with a raised margin; usually found on woody stems. When severe this is often associated with a secondary dying back of branches or twigs.

**Damping-off**: a basal rot of seedlings causing them to collapse and die.

**Dieback**: the death of stems of young twigs can be due to girdling by a pathogen at the base of the stem; vascular diseases, or physiological disorders.

**Gummosis**: usually a necrosis or swelling, associated with the exudation of gum from the tissues of stems.
**Galls and knots**: local swellings due to uneven growth, caused by the presence of a pest or pathogen.

**Leaf blisters and curls**: malformation of the leaf lamina by irregular growth induced by a pest or pathogen.

**Leaf spots**: generally consist of limited areas of necrotic tissue but in some cases the tissue may not be dead, merely discolored by the presence of causal organism. Often the spots assume characteristic shapes or have distinctive patterns. Examples are target spots (a series of concentric rings); eye spots (more or less lenticular with a central dark spot); ring spots (more or less circular with a dark margin) and shot hole where the necrotic centre of the spot falls out. Leaf spots may be surrounded by a chlorotic halo. Leaf spots caused by bacteria are often angular and on monocots are often linear. A similar range of spots may occur on herbaceous stems or soft fruits.

**Mildews**: a visible mould growth over the leaf surface, particularly on the apparently healthy margins of necrotic patches. Downy mildews (*Peronospora, Sclerospora*) and powdery mildews (*Erysiphe*) refer to two distinct groups of diseases showing different types of mould growth.

**Rots**: involve the necrosis of large areas of tissue, (often complete organs). There are different types of rot depending upon the consistency of the rotted tissue. Soft rots are caused by the dissolution of cell walls, the contents of which leak out. Dry rots (particularly of woody structures) involve absorption of the cell contents by the parasite. Rots of roots, stems, trunk etc. are usually recognised by the collapse and discoloration of the relevant part.

**Rusts**: powdery sporing pustules on the leaves or stems; usually yellow, orange, or brown in colour.

**Scabs**: raised necrotic spots on leaves, fruit or stems.

**Scald and blast**: large pale necrotic patches on leaves.

**Scorch**: necrotic, dried areas of leaf tissue; can be a prominent symptom of wilt diseases, but is also caused by nutrient deficiencies (especially potassium), by phytotoxic chemicals, and by excessive heat e.g. sun scorch.

**Smuts**: black, powdery spore masses are produced on various plant parts and often involve the transformation of some part of the plant, (often the flowers).

**Sooty moulds**: black fungal growth on leaves and stems, often associated with sucking pests such as aphids, scale insects etc.

**Stripe**: elongated leaf lesions occurring on monocotyledons and caused by pathogens limited to the vascular system.

**Witches brooms**: the proliferation of lateral buds to produce a bunch of stems.

**Symptoms of Common Disease**

Although symptoms are an unreliable guide to the identification of most plant pathogens, there are several groups of pathogens, which can attack a wide range of crops causing
common types of symptoms and diseases. Table 1 lists these commonly encountered diseases (according to the part of the plant on which symptoms are usually seen), together with the pathogens most likely to cause them. The main characteristics of these diseases, together with basic control measures, are summarized below. However, it must always be realized that the symptoms listed may be caused by other pathogens and that the pathogens listed may cause different symptoms on some crops. The particular characteristics of a symptom may also vary with environmental conditions, plant variety and pathogen strain. Where a disease is especially prevalent on a particular crop, further reference is made to it under the section dealing with that crop.

Fungal Symptoms

Damping off: It is an important disease of this crop, which is usually common in poorly managed nursery beds, incited often by the soil borne pathogens. It is responsible not only for the poor seed germination and stand of seedlings but also for carry over of the pathogens to the field where transplanting is done.

The symptoms of disease occur in two phases i.e. pre-emergence and post-emergence damping off. In the former, there is failure of seedling emergence from the soil either due to seed rots or killing of young seedlings before their emergence from the soil, hence resulting in patchy appearance of seedlings stands in the nursery in early stages of growth. In case of post emergence damping off, the disease outbreak is characterized by toppling over of infected seedlings at any time after their emergence from the soil. The infected tissue initially appears to be water soaked and soft and subsequently, the stem at the infection points get constricted resulting in toppling over and mortality of the seedlings. In the nurseries the disease usually radiates from initial infection points and thus gives the appearance of islands wherein almost all seedlings are killed.

Leaf blotch: The disease is characterized by appearance of spots on both the surfaces of leaves, being generally more numerous on the upper surface. The leaf spots first appear as pale yellow discoloration not sharply defined from the rest of the tissue, become dirty yellow and then deepen to the colour of old gold and sometimes to bay shade. The individual spots are small, 1-2 mm in diameter, which coalesce freely. The infected leaves are distorted, have reddish brown appearance and become yellow much sooner in comparison with the normal ones. The spots are discrete brownish black and mostly confined to lower leaves.

Leaf spot: The infection is usually confined to leaf blade and may occasionally extend of leaf sheaths. The disease manifests in the form of elliptic or oblong spots of variable size. In the initial stages, the spots are small and may measure 3.5-5.0 x 2.5-3.5 cm but soon they may increase in size. Two or more such spots coalesce developing into irregular patches often involving a major portion of leaf, which eventually dries up. Each individual spot has a characteristic appearance. The center is grayish white and thins with numerous black dots like acervuli on both surfaces. These are arranged in concentric rings. Beyond the greyish white portion, is a brown margin all around the spot. There is an indefinite yellowish region outside forming a halo around the spot. The spots though visible on both surfaces are more marked on the upper surface in new leaves. The field presents a scorched appearance during years of epiphytotic.
*Alternaria leaf spot*: It is a commonly occurring disease and occasionally assuming destructive status at any stage of plant growth and may cause losses to the flower crop.

*Alternaria* causes this disease in main season crop grown in plains. The fungus can affect seedlings but generally is a problem of older plants. Lowest leaves are attacked first and then the disease progresses upwards. Dark brown spots with concentric rings develop on the leaves, which give target board effect, the most characteristic symptom of the disease. In several attacks, affected leaves shrivel and fall down prematurely resulting in early defoliation.

On leaves, produces small angular scattered, light brown spots, progressing between veins towards the leaflet margin. The severely infected leaflets curl and dry out prematurely. Subsequently, the pathogen invades the adjoining healthy leaflets and gradually progresses on the foliage upward from the lower most infected leaves. Symptoms also appear on stems and branches. Water soaked spots, which soon turn light to dark brown in colour. The spots are circular to irregular often elongated and enlarge rapidly when the humidity is high coupled with frequent rains or continuous dew formation. The older lesions become dark grey in colour often encircling the branches.

On the lower most leaves, *Alternaria* spots start appearing about one month after transplanting as minute water soaked specks, which soon turn into small, circular scattered, dark brown spots. Yellow halo and the leaflet become chlorotic surround older spots. The affected leaves dry and fall prematurely.

*Septoria leaf spot*: It is widely distributed throughout the world and causes considerable loss by premature defoliation. The plant may be attacked at any stage of its growth. This fungus produces spots on the leaves, stems, the persistent calyx and the fruits. The initial symptoms appear on the lower leaves as a water soaked spots on the under surface of the leaves. As the spot grow larger, these become more or less circular in outline and show definite brown coloured margins with grey centers. A few black glistening pinhead size pycnidia may be seen within the center of spots. The disease on the stems appears as small, slightly elongated, dark spots containing numerous black pycnidia. Small-elongated specks appear on calyx, which are intermediate in size as those found on the leaves and stems. Black circular spots may also be seen on young as well as mature fruits.

*Spike rot, Root rot and Collar rot*: The initial symptoms appear as water soaked areas with purple brown margins on calyx or corolla. The infection extends very fast and results in complete rotting of flowers and failure to form capsules. The whole spike becomes slimy, soft and watery. Yellowing of seedlings is the main symptom of the disease in the nurseries while the pseudostems are attacked near the ground level. The affected portion becomes constricted, watery and soft as a result of which seedling collapse. Roots of affected seedlings are destroyed completely.

*Wet rot*: The general symptoms of the disease are first noticed as slightly pale leaves. The yellowing starts from leaf tip and spreads down the leaf blade, more along the margin than at the centre. The dead leaves droop and hang down along the pseudostem till the entire shoot becomes dry. The basal portion of the plant between the point of attachment with rhizome and collar region or the plant between the point of attachment with rhizome and collar region of pseudostem is also affected and exhibits a pale transluscent colouration, later becoming water
soaked and soft. The whole shoot either topples down or can easily be pulled out from this point with a slight pressure.

**Dry rot:** In case of dry rot symptoms, though the leaves become pale but no soft rot of collar region is observed. Such plants cannot be easily pulled out. Mycelial growth in the form of white, peach or buff coloured cushions can be seen on the surface of rhizomes. In some cases other fungi and bacteria follow and hasten the rotting process. Foul smell emits from the rotten rhizomes.

**Storage rots:** During storage, different fungi have been found associated with the bulbous crops corms, which result in rotting and decaying of the bulbs. These fungi include *Fusarium oxysporum* Schlechtend ex Fr., *Pythium deliense* Meurs and *P. myriotylum* Drechs. (*Geotrichum candidum* Link, *Aspergillus flavus* Link ex Fr., *Cladosporium lennissimus*, *Gliocladium roseum* Bainer, *Graphium album* (Corda) Sacc., *Mucor racemosus* Fresen., *Stachybotrys sansevieriae*, *Thanatephorus cucumeris* (Frenk) Donk and *Verticillium chlamydosporium* Goddard. *Geotrichum candidum* causes complete rotting of corms and bulbs.

**Corm rot:** The infected plants first show progressive drying up of the leaves, which proceed first along the margins and later the entire leaf dries up. The base of the aerial shoots shows water soaked soft lesions. The root system is adversely affected with only a few decaying brown roots. As the disease progresses infection gradually passes to the corms, which begin to rot and become soft. The colour of the rhizomes is changed into different shades of brown. The disease may be confined to a few isolated plants or may occur in patches.

**Foot rot:** Dark brown leaf spots (0.5-3.0 cm) appear during foliar infections. The infection starts as water soaked spot on the lower surface of the leaf, which later becomes discernible on the upper surface with fimbriate margins and occasionally with concentric zonation. The lesions later enlarge rapidly involving 25 to 70 per cent of the lamina. During May-June, with the onset of southwest monsoon, runner shoots arising from the base of the plant are often infected. The leaves later on become flaccid and droop down. The plants show dieback symptoms. The foot rot infection occurs as wet patch at the foot region resulting in varying degree of rotting of the main stem. There is yellowing and gradual drying up of foliage. This causes sudden death of the plant. Feeder root infection causes varying degrees of root rot. It leads to reduction in canopy size, foliar yellowing and gradual plant death.

**White rot:** Mechanical injury to roots by insects, nematodes or cultural operations increase root exudations which enhances the stimulation of sclerotia germination. Infected seedlings may die before emergence or after emergence followed by symptoms similar to those caused by damping off fungi. Eye shaped lesions reported on the sheathing leaf base on the overwintering seedlings. Infection of young plants results in wilting. If the plant is old the wilt may be confined to older leaves. The tip of the leaf turns yellow and flaccid. There is greyish cottony mycelium at the stem base. Black sclerotia are also seen on the mycelia. After harvest infected bulbs may mummify. White rot appears in patches in the field. The disease incidence has been reported to be higher in dry conditions. Dissemination of disease is through infected plant material or sclerotia. The sclerotia could be disseminated though irrigation water, wind and farm machinery etc.
Downy mildew: Downy mildew is of worldwide occurrence and during extended periods of cool, humid weather, the disease can be highly destructive causing losses in both yield and bulb quality. The disease commonly starts in patches and the symptoms vary with the type of infection. Systemic infection occurs when plants are raised from diseased planting material i.e. seed, bulbs. Plants raised from such bulbs remain stunted, become distorted and light greens in colour. In humid weather, the downy growth of the fungus, which is greyish violet in colour, develops over the entire leaf surface. After a period of storage, systemically infected bulbs become soft and shriveled and the outer fleshy scale becomes partly or wholly amber in which produce oval to cylindrical spots that are slightly paler than the rest of the foliage. A greyish visible furry growth may be visible on the surface of the leaf or seed stalk during moist periods. Older leaves are attacked first and infection spreads to the sheath. Affected leaves gradually become pale green and later yellow, and diseased parts fold over and collapse. If the leaf is attacked in the middle, it droops from the point of infection and the tip dries. Lesions on seed stalks are circular or elongate, often affecting only one side of the stalk. They weaken the stalk so that it breaks over from the weight of the seed, thereby causing the seed to shrivel. The fungus also infects floral parts and may be carried with the seed. The entire plant is not killed but only undersized bulbs are produced. In dry weather with relative humidity less than 80 per cent and temperature greater than 24°C the fungal growth disappear and spots thin out, but the fungus may reappear and cause new lesions on neighboring tissues when favourable conditions prevail again.

Rust: The disease can cause serious economic losses in favourable environmental conditions. In some parts of the country, the disease is of common occurrence and may prove destructive through defoliation of the plant. Disease symptoms appear on leaves, pods and rarely on stem and branches. On leaves, the disease may appear on both surfaces but more common on the under surface. The rust pustules usually are noted first as small, slightly raised spots that are almost white in colour. These pustules enlarge to form reddish brown, sori, and upto 2 mm in diameter, containing the rust spores. After coalescing they may occupy larger areas. A ring of secondary sori may develop around the original infection on susceptible varieties. Telial stage is dark brown to black coloured and linear. Leaves may turn yellow and dry or they may fall off.

Verticillium wilt: The wilt organism is widespread which is omnivorous infecting number of herbaceous and woody plants. In young plants dwarfing is common, which is followed by wilting of leaf blade, upward rolling of leaf margins, irreversible wilting and leaf abscission. The tips and margins of leaves first turn yellow and then brown. Leaves remain under water stress for 2 to 3 days before wilting. Pathogen colonization appear to be favoured by passive transport of conidia in the xylem stream. Symptom expression in leaves is preceded by extensive colonization, associated with gummosis of xylem vessels in petioles and veins. The woody vascular tissues of the stem develops a brown discolouration near the soil line which often proceed up to the stem and into the lower branches.

Fusarium wilt: The disease has also been reported to occur from different parts of India. The initial symptoms are seen at or after blossoming time. Foliage becomes yellow with the leaflets and stipules curling downwards and inwards, a typical symptom of vascular disease. The foliage withers from the base of the plant upwards, and death ensures before pod formation or before swelling. The root system visually appears normal but when sectioned longitudinally, vascular
system looks yellow to orange colour. This vascular discoloration may extend upto basal stem of the infected plant. After death of the host the pathogen grows out of the vessels and a white stromatic mycelium with heavy sporulation is found on the stem surface, especially under conditions of high humidity. Near wilt symptoms are similar to those of wilt but develop more slowly.

**Fusarium root rot**: *Fusarium* root rot is distinct from *Fusarium* wilt but commonly found in association with wilt and other root diseases. The diseases adversely affect the plant stand causing significant yield losses and under favourable environmental conditions it can cause even complete failure of the crop. The disease is worldwide in occurrence and reported from different parts of India. The above ground symptoms are not well defined and consist of poor growth, yellowing and finally wilting of the leaves. The cortex of the host root and hypocotyl become blackened and rotten, resulting in chlorosis and stunting of the plant. Often there is a brilliant red discoloration of the root vascular system but it does not progress above the soil line. The external root colour becomes dark reddish brown, especially at the ground line and in the seed zone. The pathogen is rarely isolated from above ground plant parts. The lower root system may be completely decayed.

**Grey mould**: Attacks of the grey mould are not uncommon on many ornamentals. The fungus associated with grey mould disease of ornamentals of field and in transit is *Botrytis cinerea* Fr. Large watersoaked grey or brownish patches appear, which soon become covered with grayish powdery fungus growth consisting chiefly of the conidiophores and conidia of the pathogen and eventually black small sclerotia form on the rotting tissue on corms, bulbs, flowerbuds and flowers. The attack on the buds often originates in injured leaves or on foliage damaged by other fungi, where *Botrytis* becomes established for initiating further infection. The grey mould fungus often follows *Phoma lingam* and the development of dry rot may be more or less masked, as *P. lingam* may be suppressed to a large degree by *Botrytis*, which causes large soft water soaked areas to develop.

**Greenhouse Diseases**

**Botrytis-incited diseases of major crops**: *Botrytis cinerea* is a ubiquitous pathogen which causes severe losses in many fruit, vegetable and ornamental crops and which can be especially important in greenhouse production. The pathogen infects the leaves, stems, flowers and fruits; in greenhouse ornamentals, it causes necrotic lesions on leaves. During severe epidemics the entire foliage may be destroyed. Stems of plants can be infected either by invasions of the fungus through the petiole or by direct infection of wounds after pruning and harvesting. Such infection may ultimately girdle the stem, kill the entire plant and cause substantial yield losses. Infected flowers of several crops may remain quiescent in the developing fruit. On fruits *B. cinerea* causes a typical rot that is frequently covered by a grey mould and that may serve as a source of inoculum within the crop. The pathogen also induces a characteristics symptom termed ‘ghost spot’, which is characterized by small, necrotic lesions, usually surrounded by a bright halo. In greenhouse flower crops such as rose and gerbera, small necrotic lesions are observed on petals. Low vapour pressure deficit (high relative humidity), free moisture on plant surfaces and cool weather factors which promote infection by *B. cinerea*. Optimum temperatures for infection are between 10 and 20° C, but infection could occur even at 2°C and above 25°C.
Conidia of *B. cinerea* require nutrients for germination and for subsequent germ tube growth on the host surface. Restricted availability of nutrients results in reduced infection rate.

Growers rely heavily on fungicides to control Botrytis incited diseases. Both spraying of fungicides on the whole canopy and application of fungicides directly to sporulating lesions on wounds are practiced. However, it has been shown that the pathogen may develop resistance against specific fungicides within a relatively short time, and resistance against benzimidazoles, dicarboximides, diethofencarb and two sterol biosynthesis inhibitors has been found. One of the alternative methods to control *B. cinerea* diseases currently practiced in greenhouses is prevention of canopy wetness by intensive heating and ventilating. This is in general, effective against infection of leaves, flowers and fruits, but not against stem infections. The fact that stem infections can be initiated up to 10 weeks before the symptoms are observed complicates the management of these damages. Furthermore, the current heating regimes in some countries are very energy-intensive and expensive.

**Powdery mildews:** Most of the ornamental plant grown in greenhouses suffers from powdery mildews. The most important fungi causing powdery mildew in greenhouse crops are *S. pannosa* var. *rosae*, which damages roses. The initial inoculum of powdery mildews consists mostly of conidia. Inoculum is easily transferred from greenhouse crops to the open field and vice versa. However, ascospores may also play a role. Powdery mildew conidia are self-sufficient in water and nutrients and although infection is favoured by low vapour pressure deficit, can be severely damaged when immersed in water on the plant surface. Powdery mildews are characterized by grey to white sporulating colonies on the upper leaf surface; symptoms may also appear on the lower surfaces and on stems and flowers in severe epidemics. Powdery mildew fungi are obligate parasites. With the exception of *L. taurica* which is endophytic, they grow on the surface of the host and form haustoria into the epidermal cells, through which nutrients are obtained. The host plant is rarely killed, but severe losses can occur owing to the reduction of photosynthesis, changes of the physiology in the host plant and utilization of nutrients by the pathogen. The temperature requirements of the fungi overlap with the conditions generally prevailing in greenhouses up to a maximum of about 30-35°C. Therefore, climate control in greenhouses is generally not effective against these diseases.

**Canker:** The most damaging phase is the development of cankers on the limbs, trunks and branches. On larger limbs, cankers usually develop on their upper surface as reddish brown, sunken lesions, which may remain small and cease to extend but in many cases, these lesions continue to extend in size, darken to smoky color. The bark beneath trough exterior is dry, hard and tough which is a characteristic feature of the disease. The cankerous lesions develop lengthwise more rapidly and are elliptical on limbs and branches. Numerous pimples like protuberances may be abundant over the bark of blighted twigs or along the margin of the canker.

**Bacterial Spots and Blights**

The most common types of bacterial diseases of plants are those that appear as spots of various sizes on leaves, stems, blossoms, and fruits. In some bacterial diseases the spots continue to advance rapidly, and the diseases are then called blights. In severe infections the spots may be so numerous that they destroy most of the plant surface and the plant appears
blighted, or the spots may enlarge and coalesce, thus producing large areas of dead plant tissue, and blighted plants. The spots are necrotic, circular or roughly circular, and in some cases surrounded by a yellowish halo. In dicotyledonous plants large veins restrict the bacterial spots on some hosts, and the spots appear angular. For the same reason, bacterial spots on monocotyledonous plants appear as streaks or strips. In humid or wet weather, infected tissue often exudes masses of bacteria that spread to new tissues or plants and start new infections. In such weather, dead leaf tissue often tears up and falls out, leaving holes that are round or irregular in shape with ragged edges.

Almost all bacterial spots, blights wilts of leaves, stems, and fruits are caused by bacteria in the genera *Pseudomonas* and *Xanthomonas*. *Pseudomonas aceris* (leaf spot of acer), *P. barberidis* (leaf spot of berberis), *P. solonacearum* wilt of cosmos, dahlia, sunflower, hydrangea, balsam, petunia, zinnia. *Xanthomonas begoniae* causing leaf spot of begonia, *Xanthomonas compestris*, causing wilt of wall flower, *X. diffenbachiae* causing leaf spot of diffenbachiae. In the bacterial spots and blights routine diagnosis of the disease depends on the morphology of the symptoms, the absence of pathogenic fungi, and the presence of bacteria in recently infected tissue. Microscopic distinction among these pathogens is impossible, as it is among most plant pathogenic is impossible, as it is among most plant pathogenic bacteria. The bacteria overwinter on infected or healthy parts, especially buds, of perennial plants, on or in seeds, on infected plant debris, on contaminated containers or tools, and on or in the soil. Their spread from the place of overwintering to their hosts and from plant to plant takes place by means of rain, runoff, rain splashes, windblown rain, direct contact with the host, insects such as flies, bees and ants, handling of plants, and tools. Penetration takes place through stomata, hydathodes, and injuries. Water soaking of tissues during heavy rains heavy rains greatly favors penetration and invasion by bacteria. Bacteria multiply on walls of host cells, which collapse after disruption of the cell membrane.

**Bacterial galls**: Galls are produced on the stems and roots of plants infected primarily by bacteria of the genus *Agrobacterium* and by certain species of *Pseudomonas, Rhizobacter, and Rhodococcus*. The galls may be amorphous, consisting of overgrowths of more or less unorganized or disorganized plant tissues, as are most *Agrobacterium* and *Pseudomonas* galls, or they may be proliferations of tissues that develop into more or less organized, teratomorphic organs, as are some *Agrobacterium* and *Rhodococcus* galls. The bacterial species that cause galls and the main diseases they cause are the following. *Agrobacterium*, causing crown gall of many woody plants, eg. Roses *Pseudomonas*, causing the olive knot disease and the bacterial gall of canker of oleander (*P. syringae* subsp. *savastanoi*).

**Plant Viruses**

Almost all viral diseases seem to cause some degree of dwarfing or stunting of the entire plant and reduction in total yield. Viruses usually shorten the length of life of virus-infected plants, although they rarely kill plants on infection. These effects may be severe and easily noticeable, or they may be very slight and easily overlooked. The most obvious symptoms of virus-infected plants are usually those appearing on the leaves, but some viruses may cause striking symptoms on the stem, fruit, and roots while they may or may not cause any symptom development on the leaves. In almost all virus diseases of plants occurring in the field, the virus is present throughout
the plant (systemic infection), and the symptoms produced are called systemic symptoms. In many plants inoculated artificially with certain viruses, the virus causes the formation of small, chlorotic or necrotic lesions only at the points of entry (local infections), and the symptoms are called local lesions. On the other hand, many viruses infect certain hosts without causing development of visible infection certain hosts without causing development of visible infection certain on them. Such viruses are usually called latent viruses, and the hosts are called symptomless carriers. In other cases, however, plants that usually develop symptoms on infection with a certain virus may remain temporarily symptomless under certain environmental conditions (e.g., high or low temperature), and such symptoms are called masked. Finally, plants may show acute severe symptoms soon after inoculation that may lead to death of the host; if the host survives the initial shock phase, the symptoms tend to become milder (chronic symptoms) in the subsequently developing parts of the plant, leading to partial or even total recovery. In some diseases, however, symptoms may progressively increase in severity and may result in gradual (slow) or quick decline of the plant. The most common types of plant symptoms produced by systemic virus infections are mosaics and ring spots. Mosaics are characterized by light-green, yellow, or white areas intermingled with the normal green of the leaves or fruit, or of lighter colored areas intermingled with areas of the normal color of flowers or fruit. Depending on the intensity or pattern of discolorations, mosaic-type symptoms may be described as mottling, streak, ring pattern, line pattern, veinclearing, veinbanding, or chlorotic spotting. Ring spots are characterized by the appearance of chlorotic or necrotic rings on the leaves and sometimes also on the fruit and stem. In many ring spot diseases the symptoms, but not the virus, tend to disappear later on.

The characteristic symptoms of leaves are listed as below:

**Yellowing**: a loss to some extent of the normal green colour of the leaves. It may affect the entire leaf, leaf edges or leaf veins. When localized in patches, yellowing is known as variegation and takes four main forms:

**Mosaics**: yellowed area of varying sizes but usually angular in form through restriction by veins. On monocotyledonous plants with parallel veined leaves, mosaics take form of streaking while when bands of either dark or light cells occur along the main veins, the effect is known as vein banding. Related to the latter symptoms is that of vein clearing, in which the veins become clear and translucent rather than yellowed.

**Mottles**: yellowed areas of more rounded or diffuse shape; commonly distributed in the same way as mosaics. Sometimes intermediate symptoms occur between the two. Small intermediate symptoms occur between the two. Small irregular mottles may be known as blotches, dots, flecks, spots or similar descriptive terms.

**Ring spots**: rings of yellow or pale green tissue with normal green centres, or concentric rings of light and dark tissue.

**Line patterns**: irregular single or multipleyellow or pale green lines and bands taking many forms, one of the most characteristic resembling the outline of an oak leaf and known as oak leaf pattern.
**Malformation**: may take many forms, the most common being known descriptively as crinkling, crumpling, curling, narrowing and rolling. Very characteristic are the outgrowths from leaves known as enations while sometimes leaves of virus affected plants display epinasty, the more rapid growth of the surface of the leaf or its stalk, resulting in pronounced downbending.

**Necrosis**: death of selected tissues resulting in patches in the form of spots, ring spots or other shapes.

**Grassiness**: the excessive proliferation of leaves on monocotyledonous plants; almost invariably mycoplasma induced.

**Flower Symptoms**:

*Flower breaking*: a very characteristic symptom and the first virus induced effect ever to be described in plants. Dark flowered plants show either darker, or more usually, white or yellowish streaks and patches on the petals. No comparable effects occur in plants with white or yellow flowers.

*Green flowers*: a greater or lesser degree of green colour to the petals, usually with other flower malformations, such as dwarfing, or phyllody; the development of leafy outgrowths. Almost invariably mycoplasma induced. Plant viruses are transmitted from plant to plant in a number of ways. Modes of transmission include vegetative propagation, mechanically through sap, seed, pollen, dodder, and specific insects, mites, nematodes, and fungi.

**B) SYMPTOMS OF DAMAGE BY INSECTS**

In the study of crop damage and crop pests the identification of the damaging organism is usually made easier by finding the pest near the damage on the plant. With insect and mite pests it is more usual for the pest to remain relatively static, so it may often be found near the site of the damage, particularly if the damage is recent. There are, however, occasions when only the damaged plant is found; or else there may be several pests found on the crop and it may not be immediately evident which insects are responsible for which damage. The damage done to different parts of the plant body is often characteristic either of a specific pest or at least of certain groups of insects and mites. Thus the experienced plant protection scientist will usually be able to make a fairly accurate guess about the identity of the damaging animal.

**Insect damage**: There are three main types of crop damage done by insect, mite and nematode pests, related to their mode of feeding. These are the more generalised insects. They feed by biting pieces of plant material and chewing. The groups concerned are the Orthoptera (grasshoppers, locusts, crickets, etc.), larvae of Lepidoptera (caterpillars) and sawflies (Hymenoptera, Symphyta), adults and larvae of many beetles (Coleoptera) and others. Dipterous larvae have either simple biting mouthparts or else a mouth-hook structure with which they tear off pieces of host tissue. The types of damage done may be generalised, as follows:

1. Loss of photosynthesizing tissues (leaf lamina); in extreme cases defoliation may result.
2. Destruction of buds and shoots.
3. Destruction of flowers, fruits and seeds.
4. Boring and tunnelling of stems; interruption of sap flow and physical weakening of the stem; stem breakage may result.

5. Eating or boring of roots and tubers in the soil.

6. Destruction of seedlings and young plants.

7. Formation of galls on all or any part of the plant body; the larvae of Cecidomyiidae; some Chalcidoidea, Curculionidae, etc. produce substances when feeding that irritate the host plant resulting in localised tissue proliferation and gall formation.

Pests with piercing and sucking mouthparts: These pests have part or all of the mouthparts modified into piercing proboscis or stylet. Sap is sucked either from the phloem (or xylem) system, or from general tissues of foliage, roots or fruits. The main group of insects concerned is the Hemiptera, but the thrips (Thysanoptera), Phytophagous Acarina (Tetranychidae, etc.) and the phytophagous Nematodes (eelworms) all pierce epithelial and other cells suck out the cell-sap. The fruit-piercing moths (Othreis, Achaea, etc. in the family Noctuidae) with their short, stout, barbed proboscis belong in this category. Within this category are two basically different types of damage:

1. **Pests without toxic saliva** (or with only slightly toxic saliva). These insects and mites remove sap, causing tissue wilt, leaf curl, stunting, and in extreme cases, death of the host plant. The Homoptera causes, death of the host plant. The Homoptera mostly come into this category; but it is now clear that some aphids, mealybugs and leaf hoppers do have slightly toxic saliva. The mites and thrips usually feed on younger leaves causing surface scarification and leaf curl or distortion.

2. **Pests with toxic saliva.** The Heteroptera (and apparently a few Homoptera) with toxic saliva cause a disproportionate amount of damage in relation to insect numbers. The toxins cause death of the cells and, if injected into a young shoot, all the shoot distal to the feeding site may die. Typical damage includes leaf tattering on buds and young leaves, spotting and/or premature fall of fruits, and the death of flowers and seeds. The necrotic areas typically become infected with fungi and bacteria and rot results. Plant parasitic nematodes have piercing stylet with which they enter the host plant tissues either for feeding or else to live there. *Meloidogyne* produce large swollen 'knots' on the host roots from which they get their common name of 'root-knot nematodes'. Other species induce galls and various deformations of the host tissues.

Pest that are vectors of pathogens: These insects (and some Nematode) are extremely important, for a very small number of infective individuals may be responsible for a severe outbreak of disease, and disease control of destruction of vectors is a difficult matter.

1. **Indirect vectors:** This category includes those insects that make feeding punctures which subsequently become infected by aerial spores; this typically occurs with fruits tunnelled by fruit fly larvae (Tephritidae) and fruitworms (Lepidoptera). Some Heteroptera may actually carry fungal spores in their saliva and these are injected into the host plant at feeding. Many insects can carry fungal spores
2. **Direct Vectors**: These insects and nematodes are sometimes called ‘biological vectors’. They are responsible for ‘active transmission’, because they are often also intermediate hosts in that some necessary developmental stage takes place within the body of the insect (or nematode). The pathogens are the plant viruses, which can only be transmitted by these vectors. Pests acting as such vectors are the insect groups Aphididae, Cicadellidae, and Delphacidae, etc., within the Homoptera, some mites and the nematodes *Xiphinema*, *Trichodorus* and *Longidorus* responsible for the transmission of the so-called ‘soil-borne viruses’.

Pest damage can be grouped according to the part of the plant body attacked. There are six categories:

1. Sown seeds and seedlings.
2. Fruits and seeds.
3. Flowers and buds.
4. Leaves
5. Stems.
6. Roots and tubers.

**Symptoms of Damage Caused by Common Insects**

**Aphids**: Small sap-feeding insects generally 1-5 mm long with soft bodies, relatively long legs and antennae and usually a conspicuous pair of tube-like structures, the siphunculi, at the end of the abdomen. Body colour varies between species and sometimes within species and ranges from white through various shades of red, yellow, orange, green, brown and blue to black. Aphid colonies often consist of winged and wingless individuals and the winged aphids have two pairs of broad, transparent wings with conspicuous dark veins. They are weak fliers but can be carried in thermals and air currents for hundreds of miles and this is how many species disperse and migrate to new host plants. Aphid mouthparts contain very fine stylets, which are inserted into plant tissues so that plant sap can flow up minute canals in the stylets and so enter the aphid's digestive system. Both young and adult aphids feed almost continuously and colonies are commonly found on leaves, buds, stem, roots and flowers. Large volumes of sap are ingested by most species and excess sugars and water are excreted as drops of a sticky substance, commonly known as honeydew. This usually falls from the aphids or is flicked away by the hind legs but some aphid species are tended by ants which feed on honey dew and give the aphid colonies some protection from predators and parasites. Aphids are one of the most important groups of pests attacking garden plants and are well known to gardeners. They are often referred to as blackfly, greenfly or blight and common names are used locally in different countries and regions. Primary damage to plants results from the effects of colonies feeding on young tissues, which weakens and distorts new growth. Secondary effects, which are often more important, result from fouling of leaves and stems with honeydew, which encourages the growth of sooty moulds and from the transmission of viruses which are carried from diseased plants on the stylets and in the saliva.

**Scale insects**: Small sap-feeding insects nymphs and mature females of which produce characteristic white, yellow or brown wax scales up to about 5 mm long covering their relatively
featureless bodies. Scales generally remain static on plants and feed by inserting fine stylets into plant tissues but may occasionally move to new feeding sites. Males are 1-2 mm long, with a single pair of wings but are absent or rare in parthenogenetic species. Colonies of nymphs and mature females infest leaves, stems or fruits. All stages feed on sap and most species excrete honeydew, which makes plants sticky and encourages growth of sooty moulds. The extent of this contamination often seems out of all proportion to the number of scales present and a few young nymphs on the undersides of the upper leaves can cause extensive fouling of the older foliage. Persistent infestations weaken growth as well as making plants unsightly. Some fruits are attacked, especially peaches, nectarines and grape vines, but scale insects are mainly pests of ornamental plants.

Glasshouse mealy bugs: Mealybug colonies develop on leaves, stem, buds, flower, fruits and other aerial parts of plants. Roots are sometimes infested by root mealybugs. Colonies contain young and mature mealybugs clustering together and protected by white wax powder and filaments, which often completely cover the insects, especially when they congregate in leaf axils, in the necks of bulbs and on the spines of cacti. Persistent infestations weaken plants, especially when growing points are attacked, and foul plant surfaces with honeydew and sooty moulds. Many different host plants are attacked and the following are particularly susceptible: vines, anthuriums, asparagus fern, begonias, cacti, ceanothus, chrysanthemums, codiaeums, coleus, crassulas, dracaenas, eucharis, ferns, ficus, fuchsias, gardenias, hippeastrums, robinias, saintpaulias and palms.

Root mealybugs: Colonies of root mealybugs develop on roots and on bases of stems of many different plants. Root mealybugs may be confused with root aphids and with springtails. Severe root mealybug infestations interfere with normal root function and plants do not grow well and may wilt, especially if they are growing in pots. Damage is generally worst when plants are growing in dry potting composts or in dry borders. Abutilons, acacias, cacti and succulents, cassias, correas, dianthus, dracaenas, gardenias, grevilleas, olearias, pelargoniums, saintpaulis, and stephanotis are particularly susceptible.

Thrips: Small, elongate, cylindrical insects up to 3-4 mm long. Adults, commonly known as 'thunder flies', have two pairs of very narrow wings fringed with long, fine hairs. Colour varies with species from white through shades of yellow to brown and black. Larvae resemble adults but lack wings and are generally lighter coloured. Larvae and adults of most species feed on plants, especially on flower and buds, but some prey on mites, aphids and other small invertebrates. Mouth-parts of larvae and adults are adapted to pierce plant or animal tissues superficially and to extract cell contents. Direct damage to garden plants is caused by large number of thrips feeding on leaves, flowers and buds, producing characteristic light mottling and silvering and some distortion.

Caterpillars: Caterpillars are larvae of moths and butterflies and all have a generally similar structure, which resembles that of some sawfly larvae. The head is well developed and has a pair of strong mandibles which are used to bite and chew plant tissues; the thorax is three segmented, usually with a pair of jointed legs on each segment, and the abdomen consists of ten segments bearing up to five pairs of fleshy, non-jointed legs. Size and colour pattern vary with species. Caterpillars of most species feed on wild plants but at least fifty species are widespread pests of garden plants.
Beetles: Beetles comprise the largest order of insects with more than 250,000 species. The forewings of adult beetles are characteristically modified to form a pair of hard wing-covers (elytra), which hinge over the abdomen and over the membranous hind wings. The head is generally relatively small but well developed, with prominent eyes, a pair of antennae, and strong mouthparts capable of biting and chewing hard or soft food. Size of pest species varies from very small (1 mm long) to large (3 cm long). Most species are black, grey or brown but some are brightly coloured. Reproduction normally is sexual but a few species are parthenogenetic. Females lay eggs on the near food, depositing them singly or in clusters. Larvae vary considerably in structure from active, predaceous types with three pairs of well developed thoracic legs and hard, pigmented bodies to relatively inactive, colourless, legless, maggot-like larvae with soft bodies. Most larvae have a well-developed head with biting mouthparts. Both adults and larval feed and their feeding habits are varied. Predators (ground beetles, ladybirds) feed on other insects and small invertebrates and may therefore be beneficial in gardens. Some groups are aquatic (dyticid and whirligig beetles); others feed mainly on dead wood and many species feed on living plant tissues and are pests of cultivated and wild plants.

Mites: Mites differ from insects in having four, not three, pairs of jointed legs in the nymphal and adult stages and in lacking any clear division of the body into head, thorax and abdomen. They are generally small (1-2 mm long) or very small (less than 0.5 mm long) and are extremely abundant in most terrestrial habitats. Many species are general scavengers, feeding in soil, in decaying organic matter and in similar situations; others prey on small invertebrates, including other mites and many species of insect, and some feed on healthy plant tissues and may therefore be pests of cultivated and wild plants. Reproduction is generally sexual and the main stages of development are egg, larva, various nymphal stages and adult. Males are absent or rare in some species and reproduction is then parthenogenetic. Despite their relatively small size, mites are often serious pests of cultivated plants since they are able to breed rapidly when conditions are favourable and they are often less susceptible to chemical control than many insects.

C) SYMPTOMS OF DAMAGE BY NEMATODES

Plant parasitic nematodes are minute roundworms often of microscopic size and are primarily soil inhabiting. Most are parasites of plant roots although some are important parasites of stem.

Root-knot nematodes (*Meloidogyne* spp.): The above ground symptoms are generally atypical; axial swellings (galls) are produced on the root. The root growth is hampered and sometimes a number of lateral roots are produced just above the gall giving rise to excessive branching (witches broom) symptoms. The depth of the root and their ability to absorb and conduct water and nutrients are reduced, thus resulting in yellowing and stunting of the shoot if the population density invading the root exceeds a certain injury threshold level. Since the population density and distribution in a field vary considerably from spot to spot, the symptoms on the crop are seen as patches of chlorotic, stunted growth. These symptoms are often mistaken for nutrient or water deficiency, the confusion is compounded since application of extra doses of fertilizer or water may ameliorate the symptoms to some extent. The plant shows slow growth.
Cyst nematodes (Heterodoera): In all the cyst nematodes the J2 is the infective stage which penetrates the root and establishes a feeding site characterized by syncytia formed by hypertrophy and breaking of cell walls of adjoining root cells. Generally, no hyperplasia or gall formed occurs. After feeding the J2 swells and becomes sessile, moult.s three times in succession and produces adult swollen round or lemon shaped and white females or vermiform males. The female breaks out of the cortex and protrudes outside the root at least partially giving a pearly appearance to the root. In some species like H. cajani a large eggsac is also produced, but in most other species a very small or no eggsac is produced. The tough leathery cyst formed by dead female protects the eggs and encysted hatched J2 against quick desiccation and ensures their survival for several months or years. In certain species, like G. rostochiensis and G. pallida eggs may not hatch even for several years without host root diffusate. Species of temperate origin and preference like H. avenae, G. rostochiensis and G. pallida have only one generation in a growing season but the other species of tropical preference like H. cajani, H. zeae, H. sorghi, H. oryzicola etc. are multivoltine.

Reniform nematode (Rotylenchulus reniformis): The symptoms of damage on the shoot are atypical, expressed as general unthrifty, chlorotic, stunted plant growth. The root injury may be seen as discoloration and epidermal cell necrosis, but the infection can be confirmed by observing the tiny females protruding from the carefully removed root often with gelatinous egg matrix and adhering soil particles.

Root lesion nematodes (Pratylenchus spp.): The genus Pratylenchus, known as lesion nematodes because of the characteristic necrotic lesions on roots of host plants.

Ectoparasitic nematodes: A large number of tylenchid and dorylaimid nematodes feed on the roots and other underground plant parts. They are widely distributed, polyphagous and usually attain high population densities under most crops. A number of pathogenicity studies have proved their potential to cause reduction in growth of plants. However, since they produce no typical symptoms of damage on root or shoot except general chlorosis and stunt growth, it is very difficult to realise the damage caused by them.

The commonly found Ectoparasitic nematodes in India are species of:

1. Tylenchorhynchus
2. Merlinius
3. Quinisulcius
4. Helicotylenchus
5. Hoplolaimus
6. Hemicriconemoides
7. Paratylenchus
8. Xiphinema
9. Longidorus
10. Trichodorus

They feed on root hair, epidermis and cortex of the roots, thus reducing the nutrient and water uptake by the roots. These nematodes no doubt cause lesser damage than the endoparasitic or semiendoparasitic nematodes at identical population densities. However, not only high population densities but also polyspecific populations are most commonly encountered in all fields. Even if it is present, only a small proportion of damage per unit area, the amount of crop loss over the large area and almost the entire range of crops would make it easy to deduce that enormous losses are caused by these ectoparasites to the agricultural production.
Traditionally pest has meant that use of chemical pesticides. Even today, pest control is still largely dependent on the use of synthetic chemicals. Over the years, the injudicious use of pesticides has resulted in a number of serious detrimental side effects. At first, there were minor hints of trouble but these have rapidly become alarming. There are more and more reports of resistance of pests to pesticides. The number of pest outbreaks has increased (resurgence) and many innocuous insect species have attained the status of serious pest in recent years. The contamination of soil, water and air incidence of high amounts of pesticide residues in food are of great concern. In 1962, Rachel Carson in her book *Silent Spring* aroused worldwide concern about the excessive use of pesticides, which eventually led to the concept of integrated pest management (IPM) as an environmentally sound alternative to the sole use of chemicals. Agenda 21 of the United Nations Conference on Environment and Development (UNCED) at Rio de Janeiro in June 1992 identified integrated pest management and control in agriculture as one of the requirements for promoting sustainable agriculture and rural development.

**What is Integrated Pest Management (IPM)**

In 1967, a FAO (Food and Agriculture Organisation of the United Nations) panel of experts defined IPM as: “A pest management system that, in the context of the associated environment and the population dynamics of the pest species, utilizes all suitable techniques and methods in as compatible a manner as possible and maintains the pest population at levels below those causing economic injury.” IPM emphasizes the need for simpler and ecologically safer measures for pest control to reduce environmental pollution and other problems caused by excessive and indiscriminate use of pesticides.

**IPM aims at:**

- Keeping the pest numbers below harmful (economic threshold) levels instead of their eradication
- Protecting and conserving the environment including biodiversity.
- In making plant protection feasible, safe and economical even for the small farmer.

An integrated strategy for crop pest management includes use of resistant varieties, modifying agronomic practices to evade and reduce pest incidence, biological control and other novel approaches for pest suppression and only need based judicious use of chemical pesticides.

**Basic components of IPM are:**

- Cultural Methods
- Biological Methods
- Chemical Methods.
A. Cultural Methods: Cultural control may be defined as control of a pest by slight variation, introduction or suppression of farm practices which are normally adopted in the cultivation of a crop. These practices may lead to the control of diseases, insects or nematodes either by directly affecting their growth and multiplication or by minimizing the chance of their attack on plant through careful manipulation or through increase in the internal resistance of plant. They must usually be practiced in advance of time when damage by the pest starts. This is the cheapest and the most practical method of control as it does not employ extra money to be spent. In order to manage the diseases and pests by cultural practices, it is necessary to know the life history and habits of pests so that the weak point of life cycle may be pinpointed. General methods used are variation in time of planting or harvesting, crop rotation, tillage of soil, pruning and thinning, fertilization, sanitation, water management, planting of trap crops, crop refuge destruction and burning of stubbles. These practices help in reducing the pest population. Cultural practices play a major role in the control of root diseases and soil-borne pathogens generally. Because there is a large effect of adverse soil conditions in predisposing plants to infection by root pathogens, adequate nutrient and moisture levels, soil tilth aeration help to promote healthy plants. General phytosanitary practices, such as crop rotation, destruction of crop debris, and the use of clean seed or healthy planting material also have a large effect in controlling root infecting pathogens, particularly because epidemic development is slow and there is little inoculum multiplication during the life of the crop. This is in contrast to fungal disease of plant shoots, where rapid multiplication and dispersal occurs through successive generations of the pathogen. Crop rotation is particularly important for the major soil borne nematode parasites of annual crops. Many endoparasitic nematodes have adult reproductive stages which are obligately parasitic, and in the absence of a suitable host they cannot survive and reproduce. The most important group (root knot nematodes) have a wide host range so that the crops chosen in the rotation are important and this varies with the species concerned. General practices used under cultural methods are described below:

1) Use of organic manures and biofertilizers

For cultivation of flowers and ornamental plants heavy organic manuring should be done. Application of FYM/compost helps in taking care of any micronutrient deficiencies in soil. Flowers grown in soils receiving large quantities of manures result in flower production with brighter colours and lustrous foliage. Thus good quality production gets better price in the market. Application of FYM @ 10-15 ton ha⁻¹ annum⁻¹ along with soil test based on NPK is a soil fertility-building practice. Build up of secondary and micronutrient fertility of the soils, counteracting deleterious effects of soil acidity, salinity and alkalinity, and sustenance of physical and chemical soil health are the key benefits associated with continuous application of FYM. Substitution of up to 50 per cent mineral fertilizer-N by either FYM or green manure-N in different agro-ecoregions of India in Kharif sustains their productivity. Incorporation of crop residues initially depresses crop yields because the residue encourages immobilization of mineral-N. Green manure-N is as efficient as chemical fertilizer N. The FYM-amended alluvial soils require lower fertilizer N rates to maximize productivity thus effecting a saving in industrially fixed N. Incorporation of crop residues and FYM alone or in combination with green manure is a carbon sequestrating practice. Residues with wider C:N ratio and high humification coefficient possibly leave more C in soil for conversion to soil organic matter. Increase in available N and P,
promotion of the formation of the water stable aggregates, reduction in bulk density and rise in cumulative infiltration occur through increase in organic carbon content. Green manuring per se does not significantly improve organic carbon content in the tropical soils, but its benefits accrue from the substitution of the chemically fixed nutrients and enhanced biological activity. Since raising of the green manure for in situ incorporation occupies the fields and deprives the farmers of the availability of land for growing cash-generating crops, its acceptance by the farmers has not been very encouraging.

Rates of organic manure application are limited by their quantities locally available as the farmers use the cattle dung for fuel purposes and crop straw to feed the cattle. Social fabric determines the quantum of the human excreta reaching the agricultural fields and in practice counting on this organic resource for nutrient secretion at the best remains only a theoretical exercise. In rural India, cattle urine emanating from the animal sheds goes down the drains polluting the ground waters. It is an opportune time to launch a programme to direct this liquid manure to the agricultural fields. There is a strong need to integrate the use of all the on-and off-farm waste waters in a farming system approach which is true for cultivation of flowers in the field. Research on sewage sludge pellet fertilizers (SPFs) for containerized greenhouse crop found that growth of marigold increased and N deficiency symptoms were prevented by combining SPF with water-soluble fertilizers. Similarly, it was observed that application of FYM significantly improved growth parameters and yield of marigold but the effect was more prominent at lower rates of FYM. Similar results were obtained with Rose cv. Happiness where significantly higher number of flowers of 60-90 cm in length were recorded on application of FYM along with chemical fertilization, on a greenhouse trail. Beneficial effect of vermicompost was demonstrated on marigold grown on commercial horticultural mixture. There is not much information available on the use of biofertilizers in flower cultivation. However, the biofertilizers can be used in flower cultivation as is done with other crops. Biofertilizers are the products containing living cells of different types of microorganisms that have an ability to mobilize nutrients from non-usable form through biological processes. These includes nitrogen fixers (both symbiotic as wall as non-symbiotic bacteria), phosphate solubilizing bacteria and fungi, and mycorrhizal fungi, capable of mobilizing non-labile nutrients and transporting metals to and across the plant roots.

2) Disease free planting materials:

Quarantines and Inspections: When plant pathogens are introduced into an area in which they did not previously exist, they may cause much more catastrophic epidemics than do the existing endemic pathogens. This happens because plants that develop in the absence of a pathogen have no opportunity to select resistance factors specific against the pathogen and are, therefore, extremely vulnerable to attack. Also, no microorganisms antagonistic or competing with the pathogen are likely to be present, while on the other hand, the pathogen finds a large amount of available susceptible tissue on which it can feast and multiply unchecked. Experienced inspectors stationed at all points of entry into the country enforce quarantines of produce likely to introduce new pathogens. Plant quarantines are already credited for the interception of numerous foreign plant world from potentially catastrophic diseases. Plant quarantines are considerably less than foolproof, however, because pathogens may be introduced in the form of spores or eggs on unsuspected carriers, and latent infections of seeds and other plant
propagative organs may exist even after treatment. Various steps taken by plant quarantine stations, such as growing plants under observation for certain times before they are released to the importer, repeated serological tests of seed lots (mostly through ELISA), nucleic acid tests involving DNA probes and polymerase chain reaction (PCR) amplification of specific pathogen DNA sequences, and inspection of imported nursery stock in the grower’s premises, tend to reduce the chances of introduction of harmful pathogen DNA sequences, and inspection of imported nursery stock in the grower’s premises, tend pathogens. Similar quarantine regulations govern the interstate, and even intrastate, sale of nursery stock, tubers, bulbs, seeds, and other propagative organs, more important in ornamental crops. The movement and sale of such materials within and between states should be controlled by the regulatory agencies of each state.

**Use of Pathogen-Free Propagating Material**: When a pathogen is excluded from the propagating material (seed, tubers, bulbs, nursery stock) of a host, it is often possible to grow the host free of that pathogen for the rest of its life. Examples are woody plants affected by nonvectored viruses. In most crops, if the host can be grown free of the pathogen for a considerable period of its early life, during which the plant can attain normal growth, it can then produce a fairly good yield in spite of a potential later infection. Examples are crops affected by vectored viruses and phytoplasmas and by fungal, bacterial and nematode pathogens. All types of pathogens can be carried in or on propagating material. True seed, however, is invaded by relatively few pathogens, although several may contaminate its surface. Seed may carry internally one of a few fungi (such as those causing anthracnoses and smuts), certain bacteria causing bacterial wilts, spots, and blights, and one of several viruses (tobacco ring spot in soybean, bean common mosaic, lettuce mosaic, barley stripe mosaic, squash mosaic, and prunus necrotic ringspot). On the other hand, vegetatively propagated material such as buds, grafts, rootstocks, tubers, bulbs, corms, cuttings and rhizomes are expected to carry internally almost every virus, viroid, phytoplasma, protozoon, and vascular fungus or bacterium present systemically in the mother plant, in addition to any fungi, bacteria, and nematodes that may be carried on or in the mother plant. True seed, however, is invaded by relatively few pathogens, although several may contaminate its surface. Seed may carry internally one of a few fungi (such as those causing anthracnoses and smuts), certain bacteria causing bacterial wilts, spots, and blights, and one of several viruses (tobacco ring spot in soybean, bean common mosaic, lettuce mosaic, barley stripe mosaic, squash mosaic, and prunus necrotic ringspot). On the other hand, vegetatively propagated material such as buds, grafts, rootstocks, tubers, bulbs, corms, cuttings and rhizomes are expected to carry internally almost every virus, viroid, phytoplasma, protozoon, and vascular fungus or bacterium present systemically in the mother plant, in addition to any fungi, bacteria, and nematodes that may be carried on these internally in some below ground propagating organs (tubers, bulbs, corms, and rhizomes) and in or on the roots of nursery stock.

**Pathogen-Free Seed**: Seed that is free of fungal, bacterial, and some viral pathogens is usually obtained by growing the crop and producing the seed in (1) an area free of isolated from the pathogen, (2) an area not suitable for the pathogen or (3) an area not suitable for the vector of the pathogen. It is very important, and with seed-transmitted and aphid-borne viruses it is indispensable, that seed be essentially free for the pathogen, especially virus. Because the pathogen will be present in the field at the beginning of the growth season, even a small proportion of infected seeds is sufficient to provide enough inoculum to spread and infect many plants early, thus causing severe losses.

3) **Nursery methods**:

**Sanitation**: Sanitation consists of all activities aimed at eliminating or reducing the amount of inoculum present in a plant, a field, or a warehouse, and at preventing the spread of the pathogen to other healthy plants and plant products. Thus, ploughing under infected plants after harvest, such as leftover infected fruit, stems, tubers, or leaves, helps cover the inoculum with
soil and speeds up its disintegration (rotting) and concurrent destruction of most pathogens carried in or on them. Deep ploughing will bring pupae and cutworms to the surface for exposure to sun and predators. Similarly, removing infected leaves of house or garden plants helps remove or reduce the inoculum. Pruning infected or dead branches, and removing infected fruit and any other plant debris that may harbor the pathogen, help reduce the inoculum and do not allow the pathogen to grow into still healthy parts that will develop later. By washing hands before handling certain kinds of plants, such as roses, gerbera, carnations, chrysanthemum, vegetatively propagated crops. Also, frequently disinfesting knives used to cut propagative stock, such as potato tubers, and disinfesting pruning shears between trees reduce the spread of pathogens through such tools. Washing the soil off farm equipment before moving it from one field to another may also help to prevent the spread of any pathogens present in the soil. Similarly, by washing the produce, its containers, and the walls of storage houses, the amount of inoculum and subsequent infections may be reduced considerably. Wherever feasible, removal of infested crop residues such as roots, and stubble immediately after harvest is capable of removing a substantial population of endoparasitic nematodes concentrated in the roots of crops. The material removed may be exposed to sun or dried. Weed destruction and general crop phytosanitation destroys alternative hosts for oviposition in insects, also pupae in crop residues are killed.

Creating Conditions Unfavorable to the Pathogen: Stored products should be properly aerated to hasten the drying of their surfaces and inhibit germination and infection by any fungal or bacterial pathogens present on them. Similarly, spacing plants properly in the field or greenhouse prevents the creation of high humidity conditions on plant surfaces and inhibits infection by certain pathogens, such as *Botrytis*. Good soil drainage also reduce the number and activity of certain fungal pathogens (e.g., *Pythium*) and nematodes and may result in significant disease control. Appropriate choice of fertilizers or soil amendments may also lead to changes in the soil pH, which may unfavorably influence the development of the pathogen. Flooding fields for long periods or dry fallowing may also reduce the number of certain pathogens in the soil (e.g., *Fusarium*, *Sclerotinia sclerotiorum*, and nematodes) by inducing starvation, lack of oxygen, or desiccation. In the production of many crops, particularly containerized nursery stock, using composted tree bark in the planting medium has resulted in the successful control of diseases caused by several soilborne pathogens, for example, *Phytophthora*, *Pythium*, and *Thielaviopsis* root rots, *Rhizoctonia* damping-off and crown rot, *Fusarium* wilt, and some nematode diseases of several crops, especially of Easter lily, poinsettia, and rhododendron. Part of the suppressive effect is apparently a result of the release from the bark of certain substances that exhibit direct fungicidal activity; other substances that promote the growth and activity of other microorganisms, which compete with or are antagonistic to the plant pathogens, exert additional suppression.

4) Solarization

Polyethylene Traps and Mulches: When clear polyethylene is placed over moist soil during sunny summer days, the temperature at the top 5 cm of soil may reach as high as 52°C compared to a maximum of 37°C in unmulched soil. If sunny weather continues for several days or weeks, the increase soil temperature from solar heat, known in solarization, inactivates (kills) many soilborne pathogen fungi, nematodes, and bacteria near the soil surface and thereby reduces the inoculum and the potential for disease.
B. Biological Methods: A major challenge for Plant Protection Scientist is to introduce or develop new management strategies, as the more traditional controls become obsolete, and to do so without greater use of chemicals. Biological control offers many advantages to the growers and to society in general and must be pursued on all fronts. The ultimate pay-off of a more stable, sustainable, and safer food supply often produced at lower cost is worth the effort. Biological control is the direct or indirect manipulation of living natural-control agents to increase their attack on pest species. The biological relationships between control agents and pest species are rather specific, thus the control method must be worked out for each pest. Emphasis on the research and practice of biological control has steadily increased in recent years and the development of an integrated management approach can effectively amplify the economic effectiveness of biological control in certain areas. Biological control of pathogens, that is, the total or partial destruction of pathogen populations by other organisms, occurs routinely in nature. There are, for example, several diseases in which the pathogen cannot develop in certain areas either because the soil, called suppressive soil, contains microorganisms antagonistic to the pathogen or because the plant that is attacked by a pathogen has also been naturally inoculated with antagonistic microorganisms before or after the pathogen attack. Sometimes, the antagonistic microorganisms may consist of avirulent strains of the same pathogen that destroy or inhibit the development of the pathogen, as happens in hypovirulence and cross protection. In some cases, even higher plants reduce the amount of inoculum either by trapping available pathogens [trap plants] or by releasing into the soil substance toxic to the pathogen. Agriculturalists have increased their efforts to take advantage of such natural biological antagonisms and to develop strategies by which biological control can be used effectively against several plant diseases. Biological antagonisms, although subject to numerous ecological limitations, are expected to become an important part of the control measures employed against many more diseases. Fungal bioagents like *Trichoderma viride*, *T. harzianum*, bacterial antagonists like *Pseudomonas fluorescens*, *Bacillus subtilis* are being used for commercial formulation (Table 2 & 3).

Since the mid-1950’s, possibilities of controlling nematodes by introducing and/or promoting bio-control agents, especially nematophagous fungi, bacteria, predatory nematodes, mites etc. have been vigorously pursued, although with not much success at least in the field crops. The most successful among the fungi receiving current attention are *Paecilomyces lilacinus* and *Verticillium chlamydosporium* and strains of the bacteria, *Pasteuria penetrans*. The fungi, in general, have a relatively broader host range and are easier to culture on artificial media, hence these appear to offer greater chances of commercial success. However, certain health risks may be involved, if a very accurate identification and precaution is not adopted. The bacteria, *Pasteuria penetrans*, are very specific to their host nematode species and are obligate parasites. Being non-motile their encumbrance to nematode body depends upon the nematode movement. Culturing them in large quantities for exploitation in large fields is difficult. There are large number of organisms inhabiting soil which are antagonistic to nematodes, all of which constitute the important component of the environmental resistance against nematodes. Promoting such organisms, either occurring naturally or introduced through suitable alteration of the soil environment can be very helpful. Increasing the organic carbon and nitrogen contents of mineral soil through addition of organic amendments like crop residues, farm yard manures, green manuring, straw incorporation, certain cropping systems, especially those including legumes etc. have been found to promote the nematode-antagonists in soil. This type of work is less reported.
from ornamental crops. Certain organic materials, which can be used as soil amendments, have nematicidal components, besides other direct and indirect benefits. For instance, the non-edible de-oiled cakes of neem (Azadirachta indica), karanj (Pongamia glabra), mahua (Madhuca indica) etc. have been found to promote soil fertility like any organic amendments and also have nematicidal components. Such materials can be used wherever available in large quantities. As individual components these materials have been recommended to be used at 10-20 q/ha depending upon the N-levels, which makes them difficult to use over large areas in field crops. However, smaller quantities together with other methods of nematode management would be found feasible. The use of neem seed kernel powder used as seed treatment has shown some promise. Green manuring with crops like *Crotalaria*, *Sesbania* etc. has been practised since ages to improve the organic matter levels and soil structure. This also reduces nematodes. Some of their varieties like *Crotalaria spectabilis* are known to be invaded by root-knot nematodes, which are unable to complete their life cycle. Selection of such trap crops may be more useful while selecting a green manuring crop.

Biological control in Insects for ornamental crops needs validation. The general methods used are:

a) Pheromone and light traps will kill a number of male moths, but large number of traps are required for successful trapping out.

b) Predators, both human and animal, can be encouraged. Wild birds such as starlings, crows, egrets etc. are very important predators of armyworms. Spiders and insect predators in crops will eat large number of insects, and such biological control is practised very successfully in many parts of tropical world.

c) Parasites responsible for natural control should be encouraged whenever possible. The introduction of *Trichogramma* egg parasites, and others, can greatly reduce the numbers of caterpillar hatching.

d) *Bacillus thuringiensis* and other bacteria, and some fungi can be used instead of the usual insecticides to kill caterpillars.

d) Viruses specific to quite a large number of Lepidoptera are now commercially available; they can give a very good level of control of caterpillars in agricultural crops.

**C. Chemical Methods:** The strategy of a good integrated pest management programme advocates need based use of pesticides rather than calendar based use of fungicide, insecticides, or nematicides. A pesticide should be chosen on the basis of its effectiveness and minimum effect on useful insects and non-target organisms. Formulations, application methods, and timing of application are very important for effective integrated control programme.

**1. Direct Protection by Chemical Control:** One of the most commonly known means of controlling pests in the field and in the greenhouse and, sometimes, in storage is through the use of chemical compounds that are toxic to the pathogens. Such chemicals either inhibit germination, growth, and multiplication of the pathogen or are outright lethal to the pathogen. Depending on the kind of pathogens they affect, the chemicals are called fungicides, bactericides, nematicides, viricides, insecticides (Tables 4, 5, 6) or for the parasitic higher plants, herbicides. Some chemicals are broad spectrum pesticides, that is, they are toxic to all or most kinds of pathogens,
whereas others affect only a few or a single (mostly fungicides) used to control plant diseases. Most of the chemicals are used to control diseases of the foliage and of other aboveground parts of plants. Others are used to disinfest and/or protect from infection seeds, tubers, and bulbs. Some are used to disinfest the soil, others to disinfest warehouses, to treat wounds, or to protect stored fruit and flowers from infection. Still others (insecticides) are used to control the insect vectors of some pathogens. In the past, chemicals applied on plants or plant organs could only protect them from subsequent infection and could not stop or cure a disease after it had started. The great majority of these older chemicals are effective only in the plant area to which they have been applied (local action) and are not absorbed or translocated by the plants. Many new chemicals, however, do have a therapeutic (eradicant) action, and several are absorbed and translocated systematically by the plant (systemic fungicides and antibiotics). The nematicides are quick in action, are effective against a variety of nematodes and gave spectacular results. The halogenated hydrocarbons like DD, DBCP, EDB, MBR etc. had played a major role in the middle of 20th century for demonstrating crop losses due to nematodes and feasibility of their control, and thus establishment of the discipline of nematology itself. However, due to environmental considerations, these are no longer available to be used as nematicides. A large number of organophosphates and carbamates have been developed which possess nematicidal properties. Most of these also act as insecticides. The most commonly used insecticides, carbofuran and phorate are also excellent systemic nematicides. Used at 1-2 kg a.i./ha as soil applied granular formulations. They are effective against most nematodes. Phorate is usually more economical since it is available as a 10% granular formulation as against the 3% granules of carbofuran for almost a similar price. Sebuphos (Rugby) has also been found effective against root-knot nematodes. The efficacy and economics of nematicides can be improved by using them as row or spot applications. The use of nematicides for seed-dressing/dipping or seedling root-dip treatments has also been found effective in providing early protection to the young growing plants to enable their better establishment. The older plants have greater tolerance to nematodes. Some chemicals like carbosulfan at 1-3% w/w Triazophos 500-100 ppm etc. have been found effective. A few neem based formulations like Godrej-Achook at 5-10% w/w as seed dresser have been found to reduce nematode attack to young growing plants.

2. Methods of Application of Chemicals for Pest Management: Chemicals used to control plant diseases are applied directly to plants or to the soil with the help of various types of equipment.

a) Foliage Sprays and Dusts: Pesticides may act in a number of different ways and these different modes of action affect their possible use. Chemicals applied as sprays or dusts on the foliage of plants are usually aimed at control of fungus diseases and to a lesser extent control of bacterial diseases. Most fungicides and bactericides are protectants and must be present on the surface of the plant in advance of the pathogen in order to prevent infection. Their presence usually does not allow fungus spores to germinate, or the chemicals may kill spores on germination. Contact of bacteria with bactericides may inhibit their multiplication or cause their death. Some newer fungicides also have a direct effect on pathogens that have already invaded the leaves, fruit, and stem, and in this case they act as eradicants, that is, they kill the fungus inside the host or may suppress the sporulation of the fungus without killing it. Some fungicides have a partial systemic action because they can be absorbed by parts of the leaf tissues and
translocated internally into the whole leaf area. Several fungicides (e.g., benomyl, thiabendazole, carboxin, and metalaxyl) are clearly systemics and can be translocated internally throughout the host plant. Some bactericides, such as streptomycin, tetracyclines, and some other antibiotics, are also systemics, especially when applied by injection.

Some systemic fungicides, such as metalaxyl and the sterol inhibitors triadimefon and fenarimol are used as so effective in postinfection applications that they can be used as rescue treatments of crops; in other words, they can be applied effectively after infection has already taken place. This use pattern is not generally recommended, however, because it is contrary to best practices for management of pathogen resistance. Fungicides and bactericides applied as sprays are generally more efficient in creating a protective residue layer on the plant surfaces than when applied as dusts. Neither dusts nor sprays stick well when applied during a rain. Sometimes other compounds, for example, lime, may be added to the active chemical in order to reduce its phytotoxicity and make it safer for the plant. Compounds with a low surface tension, called surfactants, are often added to fungicides so that they spread better, thereby increasing the contact area between fungicide and the sprayed surface. Some compounds with good sticking ability (stickers) are added to increase the adherence of the fungicide to the plant surface. Finally, there are certain spreader-sticker compounds that have both properties.

In fields with sprinkler irrigation available, some control of foliar diseases can be obtained by applying protectant or systemic fungicides to the foliage, and somewhat to the roots, through the irrigation system (fumigation). Because many fungicides and bactericides are protectant in their action, it is important that they be at the plant surface before the pathogen arrives or at least before it has had time to germinate, enter, and establish itself in the host. Because most spores require a film of water on the leaf surface or at least atmospheric humidity near saturation before they can germinate, sprays are more effective when they are applied before or immediately after every rain. Considering that many fungicides and bactericides are effective only on contact with the pathogen, it is important that the whole surface of the plant be covered with the chemical in order to ensure protection. Some limited redistribution of fungicides between the areas covered by spray droplets generally occurs, however. For this reason, young, expanding leaves, twigs, and fruits may have to be sprayed more often, than mature tissues, since small, growing leaves may outgrow protection 3 to 5 days after spraying. The interval between sprays of mature tissue may vary from 7 to 14 days or longer, depending on the particular disease, the frequency and duration of rains, the persistence or residual life of the fungicide, and the season of the year. The same limited number of applications to protect a crop from one or many diseases. Most insecticides act by direct external contact with the target organism, either immediately on application or within a few days. Some insecticides, especially those that kill biting and chewing insects, leave a persistent residue on treated plants, and others are used as persistent poisons in traits which attracts pests to them.

b) Seed Treatment: Seeds, tubers, bulbs, and roots are often treated with chemicals to prevent their decay after planting or the damping-off of young seedlings. These chemicals may control pathogens carried on seed, tubers, etc., or existing in the soil where they will be planted. In the last 30 years, seeds have been treated with systemic fungicides in order to inactivate pathogens in infected seeds (e.g., carboxin for control of loose smut) or in order to provide the foliage of the developing plant with systemic protection against the pathogen (e.g., metalaxyl for
most of the downy mildews and blight). Chemicals can be applied on the seed as dusts or as thick water suspensions (slurries) mixed with the seed. The seed can also be soaked in a water or solvent solution of the chemical and then allowed drying. Tubers, bulbs, corms, and roots can be treated in similar ways.

In treating seeds or any other propagative organs with chemicals, precautions must be taken so that their viability is not lowered or destroyed. At the same time, enough chemical must stick to the seed is planted the chemical diffuses into the soil and disinfects a sphere of soil around the seed. In this way, the new plant will grow without being attacked at this particularly vulnerable period of growth. Most treatments of propagative stock are with organic protectant compounds such as captan, chloroneb, maneb, mancozeb, thiram, and the systemic compounds carboxin, benomyl, thiabendazole, metalaxyl, and triadimenol. Some chemicals may control specific diseases of some plants, whereas others are more general in their action and may control many diseases of a number of plants.

c) **Soil Treatment**: In addition to use in fumigating the soil with volatile chemicals (fumigants) before planting for reducing the inoculum of nematodes, fungi, and bacteria, certain fungicides are applied to the soil as dusts, drenches, or granules to control damping-off, seedling blights, crown and root rots, and other diseases. Such fungicides include, metalaxyl, triadimefon, ethazol, and propamocarb. Some of the systemic fungicides may provide season-long control from a single preplant application. In some cases, foliar diseases (e.g., downy mildews and rusts) can be controlled by incorporating the fungicide (e.g., metalaxyl, triadimenol) into the fertilizer and applying them together before planting. Protective and systemic fungicides have also been applied to the soil (and to the foliage) through the irrigation water (fumigation) for control of soilborne diseases.

d) **Tree Wound Treatment**: Large pruning cuts, and wounds made on the bark of branches and trunks accidentally or in the process of removing infections of fungi and bacteria, need to be protected from drying and from becoming ports of entry for new pathogens. Painting them with shelac or any commercial wound dressing usually prevents drying of the margins of large tree wounds. The exposed wood is then sterilized by swabbing it with a solution of either 0.5 to 1.0 per cent sodium hypochlorite (10-20 per cent Clorax bleach) or with 70 per cent ethyl alcohol. Finally, the entire wound is painted with a permanent tree wound dressing, such as a 10:2:2 mixture of lanolin, resin, and gum or Cerano, or Bordeaux paint, or an asphalt-varnish tree paint. Some wound dressings, such as Cerano and Bordeaux paint, are themselves disinfectants, whereas most others require the addition of a disinfectant, such as 0.25 percent phenyl mercuric nitrate or 6 percent phenol. It must be kept in mind, however, that asphalt-based, are phytotoxic enough to prevent, rather than promote, wound healing. In commercial orchards, vineyards, etc., where the number of wounds created during the annual pruning operations is too large to treat individually, the wounds are protected as practical with one of several fungicides, including benomyl, dichlone, and captan.

D) **TIPS FOR INTEGRATED MANAGEMENT OF COMMON FIELD PESTS**

(A) **Polyphagous Pests**

1. **White grub**: (i) Deep ploughing to encourage feeding of grubs by predatory birds.
(ii) Destruction of adults on host trees soon after the first monsoon showers by the following methods.

(a) By shaking the host trees in night (8.10 pm) congregating beetles can be collected and destroyed.

(b) The host trees should be sprayed with 0.2% carbaryl or 0.05% monocrophos or 0.05% chlophyriphos during the day time.

(iii) Seed treatment with chlophyriphos 20 EC or quinalphos 25 EC @ 20 ml/kg seed.

(iv) In endemic pockets of white grub, phorate (10G) 20-25 kg or carbofuran (3G) 30-35 kg per hectare should be applied in furrows just before sowing of the crop.

(v) Population of white grub in endemic areas may be reduced considerably, if land is left fallow for two consecutive years from June to October.

2. **Termite:**

(i) Use of well decomposed organic manure is essential to avoid termite infestation.

(ii) Flooding of field provides temporary relief and regular irrigation is useful to save the crops from termite attack.

(iii) Adding of small quantity (2-3 l/ha) of crude oil (used engine oil) or chloryripheos (20Ec) 3 l/ha with irrigation water is effective for termite control.

(iv) In termite prone areas, pre sowing treatment of soil with broadcasting of chlophyphosphos (20 Ec) 3 l or lindane (20 Ec) 4 l/ha in 10 Kg of sand was found effective for the control of termite.

3. **Nematodes (Root knot nematodes):**

(i) Two to 3 deep summer ploughing during May and June at 15 days interval to expose the nematode for scorching heat.

(ii) Nursery treatment with carbofuran @ 3g a.i./m² to grow the healthy seedlings Green manuring with sunhemp (Crotolaria juncea) should be done to reduce the population of root-knot nematode as the larvae of its penetrate the roots but fail to mature.

(iii) If nursery treatment was not done then seedlings root dip treatment with 0.5% monocrotophos for 10 hrs before transplanting should be done.

(iv) In heavy infested field Neem cake may be applied @ 1 ton/ha or the soil may be treated with carbofuran 3g @ 1.5 kg a.i./ha.

4. **Rodents:**

(i) Summer ploughing for the destruction of rat burrows to expose the animals for natural enemies.

(ii) Organisation of anti rat campaigns.

   (a) Training, regarding the rodent control strategy and precautions to be taken during pre and post operations period by the operators.

   (b) Rodent control operations: Five days plan of work to be followed as under:

   **First day**: Survey and closing of burrows.
   **Second day**: Pre baiting
   **Third Day**: Poison baiting with 2% loose poison bait of zince phosphide.

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Fourth Date: Poison baiting continued.
Fifty day: Fumigation with Aluminium phosphide.

On the observations of rodent infestations, the control operations should be done in crop fields and threshing yards during Kharif (May-June), Rabi (Sept-Oct.) and residential houses, godowns, poultry farms and cattle yards (May-June) as and when rodent menace is felt. The acute rodenticides should be used under proper case of technical personnel only in human habituated places. Trapping of rats and mice with polybutase based glue traps should be resorted to reduce the rat population.

Note: Operation with acute poison (2% L.P.B. of Zinc phosphide) followed by acute coagulants (0.005% R.P.B. of bromadiolone) and vice-versa at an interval of 20-25 days provides effective and long lasting remedy against rodents of lower down their menace below economic injury level.

PART III
DISEASES, INSECTS AND NEMATODE PROBLEMS AND THEIR MANAGEMENT OF MAJOR ORNAMENTALS

ROSE

Fungal Diseases — Fungal

Die-back (Botrydiploidia theobromae, Colletotrichium gloeosporioides, Fusarium sp. and Phomopsis sp.)

Symptoms: This is the most serious of the rose disease in India. Earlier reports suggest that this disease was caused by fungus Diplodia rosarum Fr., but in the recent years, several other fungi have been recorded to be present in the diseased twigs. These include Botrydiploidia theobromae, Colletotrichium gloeosporioides, Fusarium sp. and Phomopsis sp. As the term dieback implies, the disease causes the death of the plant from top downwards. The disease starts from the pruned surface of the twigs. Initially it may be observed to the extent to a few centimeters below the pruned end, but in the severe cases, the disease spreads further and kills the entire plant. Outwardly, the symptoms appear as browning or blackening of the twig portion near the pruned end. In the advanced stage the disease spreads from the branch twigs to the main stem and travels further down to the roots, killing the whole plant. The diseased twigs when split open reveals the infection to have traveled a few centimeters more than it appears, and the internal tissues show browning. Sometimes the flower stalks are also affected, remitting in direct losses of yields. The disease more frequently attacks the woody mature twigs of older plants than the younger herbaceous canes of younger plants. Some of the diseased twigs when cut open have been found to be tunneled through the pith from the cut end downwards, showing the presence of Digger wasps (Grabrasp.). The twigs attacked by the wasp readily dry up and frequently lead to the die back.

Management: Since the disease is usually associated with pruning, proper prophylactic measures following pruning would help prevent this disease to large extent. Coating of a pruned
end with a fungicidal paint containing 4 parts of copper carbonate, 4 parts of red lead and 5 parts of linseed oil, controls the disease effectively. Soil drenching with 2g/l Bavistin, Benomyl or Demosan, has also been reported to control the disease. M.P.K.V., Pune center has recommended spraying with 0.2 captan or 0.2% Mancozeb or 0.2% copper-oxy-chloride immediately after pruning and then twice at 10 days interval to control the die back of rose. In the Division of Floriculture and Landscaping, IARI, New Delhi more than 800 varieties were screened against this disease. None of the variety was found free of this disease. Some level of tolerance was observed in the following varieties.


**Black Spot** (*Diplocarpon rosae Wolf*)

**Symptoms**: Black spot disease has also been called leaf blotch, leaf spot, blotch, rose actinonema, and rose leaf asteroma and star sooty mold. It is the most important disease of roses all over the world. Black spot is a minor problem on glasshouse roses, because greater care is taken to avoid syringing plants with water for spider mite control and because humidity is regulated very carefully. In outdoor roses, however, this disease is generally present, frequently epidemic, and a major problem. Characteristic black spot 2-12 mm in diameter develops on upper leaf surfaces. These leaf spots are circular or irregularly coalescent with characteristic feathery, radiate, fibrillose margins of subcuticular mycelial strands. Small black acervuli are often visible on the surface and may be distributed irregularly or in concentric circles. Conidia may be visible as white, slimy masses on the acervuli. Leaf tissue surrounding the spots turn yellow and chlorosis extends throughout the leaflet until abscission occurs. The pathogen actually presents only in the lesion itself; the yellow tissue is caused by pathogen metabolites. The yellow tissue exhibits high metabolic activity that is expressed by accumulation of total phenolics and ortho-dihydroxyphenols and amino acids as well as by high enzyme activity. Spots enlarge slowly taking several weeks to reach 12 mm in diameter. In resistant cultivars or under unfavourable environmental conditions, only tiny black flecks may form and leaves may not turn yellow or abscise. Yellowing and abscission of leaflets are associated with ethylene. Leaves with black spots produce large quantities of ethylene; production decreases, as leaves become yellow and ceases when leaves turn brown. Infected leaves contain less auxin than healthy ones. The pathogen degrades this abscission-retarding material, thereby hastening less abscission. Raised, purple-red, irregular blotches develop on the immature wood of first year canes of susceptible cultivars. Spots later become blackened and blistered; they contain acervuli but lack fibrillose strands. Lesions are often small and rarely kill branches but are extremely important in the survival of the pathogen over the winter. Petioles and stipules may have inconspicuous black spots similar to those found on leaves. Petioles may be girdled without abscising. Peduncles, fruit and sepals may have similar symptoms. Petals may have red flecks accompanied by moderate distortion. Acervuli frequently occur in the lesions. *Marssonina rosae* (Lib.) Lind (*Asteroma rosae, Actinonema rosae, Marsonia rosae*), the imperfect stage of the black spot pathogen, perfect stage of pathogen is *Diplocarpon rosae* Wolf. Epidemiological studies conducted at
MPKV, Pune, showed that black spot disease mostly occurs during June to October. The disease starts after onset of monsoon and reaches maximum intensity during September-October.

**Management**: Leaves should not be allowed to remain wet or at very high humidity for more than 7-12 hours. Removing leaves from the ground and pruning canopy that contain lesions will reduce overwintering of the pathogen. Dense planting should be avoided to allow good air circulation through leaf canopy. Due to its serious destructive nature several workers in India have studied resistance to this disease under field condition. Indian varieties showing field tolerance to this disease are Ganga, Gulzar, Hans, Jawahar, Kavita, Mrinalini, Noorjahan, Prima, Pusa,sona, Pusa sonora, Raktagandha, Sadabahar, Shabnam and Suryodaya to be resistant to the disease. Varieties of exotic origin namely Babelune, Coronada, Ernest H. morse, Forty niner, Grand opera, Lucy cromphon, Sphinx and Tiara have been reported to be resistant to this disease. In the Division of Floriculture IARI, New Delhi (1989-98) out of 166 hybrid teas screened for black spot none of the variety was resistant. Sixty varieties namely Abhisarika, Alec's Red, American Heritage, Arjun, Atol, Avon, Belle of Punjab, Black Lady, Bonnie Nuit, Carina, Catherine Deneuve, Century Two, Chambe Di Kali ,Charugandha, Chitralekha, Command Performance, Confidence, Dr. B. P. Pal, Dr.S. S. Bhanagar, Doris Tysterman, Double Delight, Eiffel Tower, Flaming Sunset, Folklore, Fragrant Cloud, Galia, Ganga, Garden Party, Gladiator, Golden Giant, Golden Times, Gulzar, Happiness, Henkel Royal, Honor, Indian Princess, Jawahar, Jacquina, John F. Kennedy, Kankangini, Kardinal, Kiss of Fire, Lady-X, Lehar, Lalima, Medallion, Meckak, Mister Lincoln, Mother Teresa, Mount Shasta, Mrinalini, Orient Express, Peter Frankenfeld, Precious Platinum, Priyadarshini, RajaMohan Roy, Royal Highness, Sonia Meilland, Surabhi and Surkhab were moderately resistant. None of the 30 Indian bred rose cultivars that were screened was found resistant against black leaf spot disease. The cultivar Priyadarsini was moderately resistant (MPKV, Pune). Of the 5 rootstocks, “IIHR Thornless” and “IARI Thornless” were tolerant to the disease. Since the black spot fungus is located under the protecting cuticle, no fungicide can kill the fungus without destroying the leaves. For this reason, it is necessary to have the young leaves protected at all times against the invasion by the fungus. The infected leaves as soon as they are observed should be clipped off and burnt. Preventive sprays of Ferbam (0.1%) at fortnightly intervals, Benlate or Bayleton (0.1%) applied just before the appearance of the helps in managing the disease. Under PAU, Ludhiana condition Bavistin (0.1%) was most effective fungicide against leaf spot caused by *Diplocarpon rose*.

**Powdery Mildew (Sphaerotheca pannosa var. rosae (Wallr) Lev)**

**Symptoms**: A major disease of the rose all over the world, it develops serious proportions in India in some seasons particularly in areas with warm, humid temperature weather with cool nights. The disease affects all the aerial parts of the plant, though the leaves are found to be affected more: The younger leaves get curled, exposing the lower surface such leaves are likely to be purplish than the normal leaves. Raised blister like areas develop on these leaves, which becomes coated with the white powdery growth of the fungus. The young growing tips may get completely covered up with mildew. Badly infected flower buds fail to open. The petals are
discolored, dwarfed and finally die. Epidemiological studies conducted at MPKV, Pune, observed that powdery mildew mostly occurs during November to March, having its maximum intensity till January-February.

**Management**: Protective sprays have mainly achieved control. Uses of systemic fungicides such as benomyl and triforine have been found to be effective. Control measures outdoors and glasshouse roses differ somewhat. On outdoor roses, powdery mildew can be expected to occur when rainfall is low or absent, the temperature range is near optimal, and the humidity is high at night and low during the day. Should these conditions occur, protective sprays are necessary. The rapid production of susceptible shoots necessitates repeated application, and the timing of application is extremely important. Pruning infected shoots at the end of the season and destroying these shoots in regions where are severe will help prevent overwintering of the fungus. Raking and destroying fallen leaves from around the bushes at the end of the season may also inhibit overwintering. On greenhouse roses, powdery mildew can be expected to occur when the temperature range is near optimal and humidity is high at night and low during the day. When these conditions exist, the occurrence of powdery mildew may be forecast three to six days before it appears. Thus, protective fungicidal sprays should be applied and repeated on a seven-day schedule as long as these conditions continue. Other preventive control measures include lowering the night humidity by fans and/or venting or by heating and venting. *Rosa Multiflora* was found tolerant to powdery mildew disease, while "Edward" and *Rosa indica* var Odorata were susceptible to the disease. Under the evaluation programme of rose germ plasm against powdery mildew following lines were found to be resistant at IARI, New Delhi.

**Sources of Resistance against Powdery Mildew in Different Colours and Classes of Roses**

<table>
<thead>
<tr>
<th>Colour</th>
<th>Hybrid Teas</th>
<th>Floribundas</th>
<th>Miniatures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pink</td>
<td>Belle of Punjab, Carina, Chambe de Kali, Catherine Deneuve, Eiffel</td>
<td>Imperator, Kavita, Loree, Queen Elizabeth, Sadabahar</td>
<td>Tiki</td>
</tr>
<tr>
<td>Colour</td>
<td>Hybrid Teas</td>
<td>Floribundas</td>
<td>Miniatures</td>
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</tr>
<tr>
<td>Orange</td>
<td>Command&lt;sup&gt;1&lt;/sup&gt;, Performance, Flaming Sunset, Folklore, Galia, Just Joey, Montezuma, Nayika, Orient Express, Raja Surendra Singh of Nalagarh, Sonia Meilland Super star, Sylvia</td>
<td>Angelique, Celestial star, Flamengo, Suryakiran, Zambra, Zorina</td>
<td>—</td>
</tr>
<tr>
<td>Yellow</td>
<td>Black Lady, Cherry Brandy, Chitwan, Dutch Gold, Golden Splendour</td>
<td>Arthur Bell, Lehar, Playboy</td>
<td>—</td>
</tr>
<tr>
<td>White</td>
<td>Honor, Neelam, Prestine, Sweet Afton, White Christmas</td>
<td>Akito, Shabnam, Summer Snow</td>
<td>—</td>
</tr>
<tr>
<td>Bicolour</td>
<td>American Heritage, Anvil Sparks, Double Delight, Garden Party, Rose Gaujard, Surkhab</td>
<td>Banjaran, Chitchor, Judy garland, Pink Parfei, Prema, Sea Pearl</td>
<td>—</td>
</tr>
</tbody>
</table>

For effective and economical control of powdery mildew disease of rose, it was recommended to spray the crop with 0.5% Penconazole or 0.05% Dinocap or 0.05% Tridemorph at an interval of 10 days (MPKV, Pune). Spray of Kavach 0.2%, Dinocap 0.05% or Sulfex 0.2% at an interval of 10 days has also been recommended by the Centres of the AICRP on Floriculture.

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Grey Mold or Botrytis Blight (Botrytis cinerea Pers. Ex. Fr.)

**Symptoms**: Severe blighting of buds and twigs, during rainy season has been reported from northern Indian hills. The petals of affected buds develop brownish patches, which soon engulfs the entire surface and causes rotting. The discoloration extends below to the twigs killing them partially or wholly. Under foggy and high humid conditions abundant whitish-grey fructification appears over the surface of the blighted portions, which results in quick spread and severity of the disease. On leaves water soaked lesions are formed which spread very fast. On flowers infection develops in the form of water soaked lesions, which cause premature fading, discoloration and dropping. The infection is generally seen in the inner whorl of the flowers. During the favorable conditions the infection spreads very fast coinciding with the period of senescence.

**Management**: Spray of Bavistin (0.2%), Benomyl (0.2%) and Rovral (0.2%) at regular intervals have been recommended. Since the disease develops fast on wounded and senescent tissues it is advisable to remove crop debris and infected flowers. In Greenhouses and field try to avoid high moisture conditions and free water on leaves and flowers.

Leaf Spot is caused by Colletotrichum capsici during rainy season characterized by in the form of circular, blood red spots on rose leaves, and severe defoliation occurs.

Bud and Twig Blight is caused by Phomopsis gulabia yellowing and defoliation of leaves and light brown spots on leaves is caused by Curvularia lunata.

Glomerella leaf blight is caused by Glomerella cingulata characterized by circular and irregular spots on leaves in rose. Spraying with Benlate (0.1%) or Difolatan (0.1%) was found effective in controlling the disease.

Botryodioploidia Leaf Blight caused by Botryodiplodia jaczevski and characterized by circular and irregular leaf spots. The spots on leaves are amphigenous. Infected leaves become chlorotic and defoliate.

Rust (Phragmidium mucronatum Fr.)

**Symptom**: The symptoms at early stages include chlorotic spots on the leaf surface. The orange coloured uredial spores are commonly seen. The infection results in defoliation of the plants.

**Management**: Sprays of chemicals like Saprol (0.2%) and bayleton(0.15%) are effective in disease management.

Bacterial — Crown Gall (Agrobacterium tumefaciens)

**Symptoms**: Cauliflower like galls is produced most commonly at the crown region of the stem at the ground level. Galls are also produced on roots and on stems wounded due to harvesting, pruning and other cultural operations.

**Management**: This disease is a major problem to plant propagators. General control measures like clean nursery practices. Use of disease free planting material and removal of infected debris. Commercial formulations consisting of Agrobacterium rhizogenes (K-84) is being successfully used in many countries to control crown gall.
Viral — Rose Mosaic Disease

**Symptoms**: The infection causes a range of symptoms including mosaic patterns, mottling growth abnormalities like reduced stem length, few flowers of poor quality. The infection also causes low survival, leading to transplanting problems and reduced rate of bud success.

**Management**: General control measures are advised. Clean nursery stock of mother plants. Rootstocks should be free from viruses.

**Streak**

**Symptoms**: Brown rings and brown vein banding appear in fully expanded leaves, and brownish or greenish rings in the canes. Necrotic areas develop in the vicinity of grafted buds, resulting in stem girling and wilting of leaves. This virus is transmitted by grafting.

**Management**: Same as for mosaic.

**Insects**

**Mites**: These are minute, polyphagous pests found in large colonies on the underside of the leaves covered with fine silky webs. Due to their feeding white specks appear on the leaves and these specks coalesce and appear as white patches. Ultimately, affected leaves become mottled.

**Management**: Among the different chemicals tested against mites in polyhouse Abamectin (Vertimec) 0.5 ml/l caused highest mortality (96.98%) of the mite followed by Difenthion (Polo) (94.31%) and Amitra 2 (mitac) (92.70%) reported from IIHR, Bangalore. Among the different plant oils tested against mites, jatropha oil was found most effective causing 78.9% mortality followed by Annona oil. Both neem oil and pongamia oils 1% also caused considerable mortality 75.0% of the mite (IIHR, Bangalore).

**Rose Chafer (Cetonia aurata)**

**Symptoms**: This is a striking metallic-green beetle, up to 20 mm long. It is locally common and may be seen feeding on rose buds, flowers and leaves in June.

**Management**: Use of Endosulfan 35 EC 2ml/l.

**Scurfy Scale (Aulacaspis rosae)**

**Symptoms**: Round, flat, opaque white scales, up to 2-3mm across, form dense colonies on woody stems of certain species of rose, both outdoors and under greenhouse conditions. Males are present in this species and the male scales are elongate white fluted scales, which are smaller than females. Females lay eggs in July-August. Nymphs soon hatch and settle to feed before hibernating.

**Management**: (a) Rub off the scales with cotton soaked in kerosene or diesel or methylated spirit. (b) Cut and burn the affected branches. (c) Spray malathion 50 EC 2ml/l. Two rounds. First at the time of pruning and again during March-April.
Thrips (*Thrips fuscipennis*)

**Symptoms**: Flowers of roses and of some other plants are flecked with numerous light spots and streaks, which later darken and rot. Leaves may also show silver flecking and brown thrips are usually present on plants. Roses grown under cover may be severely damaged by infestations developing early in the season.

**Management**: Severe thrips attack on greenhouse and house plants are often associated with poor growing conditions resulting from underwatering and overheating. Regular watering and maintenance of cooler, more humid atmosphere can therefore help to prevent infestations. Similarly, infestations on outdoor plants are usually worst during hot dry periods and thrips populations are reduced in cool, wet periods. Most species are easily controlled by contact insecticides, if necessary, and malation is generally effective. Sprays should be made soon after the early infestation with a repeat application after 2-3 weeks if damage continues. Spray of vertimex 0.25% or Mavrick 0.4 ml/l was recommended by MPKV, Pune center for control of thrips.

Jassids

**Symptoms**: These sucking insects cause yellowing or whitening of the attached surface.

**Management**: The spray of metasystox or democron or soil application of Thimet can control jassids.

White Ants (*Odontotermes obesus, Microtames obesi*): Termites or white ants very often attack roses, even before they are established in the field

**Management**: Use of neem cakes was found beneficial. Chloropyriphos (0.1%) denching in rose beds or before planting is also recommended.

Red Scales (*Aomidiella aurantii, Lindigapsis rossi*)

**Symptoms**: Severe infestation occur with this insects before the rainy season in rose, characterized by the formation of reddish brown encrustations on the lower portion of the old stems.

**Management**: The encrustations of the scale insects can be removed by rubbing with cotton swab dipped in methylated spirit or by toothbrush. Spray of mesaystox (2ml/l) or rogor (2ml/l) or uses of granular insecticide like phorate or carbofuran was reported to be effective.

Red Spider Mite (*Brevipalpus phoenicis, Tetranychus cinnabarinus, Typhlodromus confuseus*)

**Symptoms**: These insects' remains on the undersurface of the leaves covered with silky web and as a result of feeding white specks appear on the leaves. With the infestation leaves turn yellow and full.

**Management**: Effective control can be achieved with the spray of wettable sulphur (3g/l) nuvacron (1ml/l) or Kelthane (2ml/l).

Mealy Bugs

**Symptoms**: The pests appear on the stalks of flowers and buds, suck the sap and hence, the rose flower bud opening is prevented and flowers wither away.
Management: Spray of Nuvacron (1 ml/l) was reported to be effective.

Aphids (Macrosiphum rosae): Common and widespread. Large dark green or pink-brown aphids feed on buds, shoots and leaves. Colonies may persist throughout the year but are most numerous and troublesome in late spring and early summer. Foliage of infested plants is fouled with sticky honeydew and sometimes with sooty molds and growth may be checked.

Management: Aphid populations tend to increase most rapidly on soft and sappy growths. Restricted use of nitrogenous fertilizers may restrict such type of growth and so check aphids. But cultural methods of such type may be doubtful to manage this insect and therefore systemic insecticides like dimethoate is recommended.

Borer: Spray of Nuracron 2 ml/l was recommended by MPKV, Pune Centre.

General Recommendation for Insect Control: The spray schedule consisting of neem Kernal extract 4%, methyl parathion 0.05%, oxydemethion 0.05% and neem oil 2% sprayed at 15 days interval provided significant control of thrips, aphids, caterpillars and beetle pastes on roses (IIHR).

Nematodes: The unproductive flowers in Rosa bourboniana and Rosa chinensis has been reported from TNAU Coimbatore which was attributed to the attack of the ectoparasites viz. Hemicycliophora labiata and Xiphinema basiri.

GLADIOLUS

Fungal Diseases

Fusarium Wilt, yellow or Corm Rot [Fusarium oxysporum f. sp. gladioli (Massee) Snyder & Hansen]

Symptoms: The characteristic symptom is interveinal leaf tip yellowing, which extends down the leaf and whole leaf gradually turns brown and become narrow. The other common symptoms include stunting, curving, arching and bending of the leaves. On advancement of infection of plant suddenly wilts or turn yellow and die prematurely. The leaf infection is usually basal and associated with corm rot. Roots arising from corms may show brown lesions. Corm rot in storage is distinct, appears dry and is very often restricted to the corm base. But in field it is characterized by soft rot, invaded by other organisms and frequently associated with brown, wiry roots. The center of the bulbs turns black and rots completely. Lesions on corms are reddish-brown with well-defined margins, round to oval, somewhat depressed leading to hard shrunken mummified corms.

Management: Resistant Varieties: Cultivars like Albana, Apricot Glow, Souvenir, Hoppman’s Glory, Sylvia, Dhiraj, White Friendship and White Prosperity are reported to be resistant while Australian fair and Mansore are tolerant to the disease. Use of resistant cultivars together with soil drench of carbendazim 4 days after planting and three times at 10 days intervals. (I.A.R.I., New Delhi) In gladiolus out of 11 cultivars tested against the disease, the cultivar “IARI Sel-1,” “Psittacinus Hyb” and “Suchitra” were found resistant (MPKV, Pune).
Cultural Practices: Crop rotation, sanitation, early lifting and proper curing of corms at 29.5 - 30°C for about one week, hot water dips of corms reduce the disease. Diseased corms should be discarded; infected and late blooming plants should by rouged from the fields early as possible. The cormels floating in water before hot water treatment should also be discarded and removal of corm scales (cataphylls). Adjustment of soil pH to 6.7-7.0 and nitrogen and nitrogen 80-90 % from nitrate sources has great impact on lowering down inoculum potential. Adequate aeration in storage, raised beds, improved water drainage and incorporation of organic mulches in soil helps in preventing corm rot.

Hot water treatment: Hot water treatment of cormels at 53-55 °C for 30 minutes + a soak or dry dressing with Sumislox (promycidone).

Use of Chemicals: Dipping of corms in one percent Potassium permanganate before storage or steeping in 0.2 % for four hours and dusting with captan gives good control. Captan, chlorothalonil, benomyl, thiaabendazole and zineb also provide effective and excellent protection. For Fusarium wilt and rot of corms of gladiolus the AICRP centres of Pune, Ludhiana and Srinagar had reported that preplanting and prestorage treatment of gladiolus corms with carbendazim (Bavistin) 0.1% and Thiram (0.3%) among systemic and Mancozeb among nonsystemic fungicide were effective. Pre sowing dip treatment of corms with Emisan-6 (0.2%) or dip the corms and cormels twice i.e. before storage and before planting for 15, minutes in the fungicidal solution followed by drenching twice at monthly intervals with captan 0.3% or Thiram 0.3% was effective against Fusarium wilt of gladiolus (MPKV, Pune and PAU, Ludhiana)

Storage rot: The fungus Penicillium gladioli is the most common cause of this disease. Other fungi reported to be responsible for storage rot are species of Aspergillus, Rhizopus, Alternaria, etc. Infection occurs through injuries.

Symptoms: The disease mostly appears in the form of black, brown, greenish or yellowish mouldy growth on the corms during storage. Under poor air circulation the corms may rot or emit a foul smell.

Management: As infection occurs through injuries, wounding of corms at the time of digging or during handling should be avoided. The corm dip treatment and the curing technique as described under 'Wilt' should be followed. Damp storage conditions should also be avoided. High temperature (more than 5°C in the cold store) needs also to be avoided, as it could lead to rapid rotting of corms under humid conditions. For the control the storage rot of gladiolus corms it was recommended by MPKV, Pune centre to dip the corms in Mancozeb 0.2%, or Thiram 0.3% or Benomyl at 0.2% for 15 minutes after harvest, dry them in shade and store in cold storage.

Dry or neck rot (Stromatinia gladioli or Sclerotinia gladioli (Drayt.) Whetz.)

Symptoms: It is also known as root rot. The disease is seen on the stored corms as small, dark, more or less superficial spots or lesions which can also produce collar rot, killing the plants or its delayed attack may only harm the new corm for carrying the disease to the next season. Dry rot is a wide spread disease attacking gladioli plants in the field and corms in storage. It is more severe during humid conditions in the field where premature yellowing occurs ultimately causing death of the plants. The leaves turn brown from the tips downwards and at leaves they
carry (neck rot), but corms remain attached to the stem firmly. Later, sheathes become shredded and covered with numerous round and black resting bodies just large enough to see. These tiny bodies and the absence of grey spore masses differentiate this disease form the *Botrytis* stem rot newly rotted neck tissues are yellow brown with moldy odor. Diseased corms show numerous round black and small lesions (first reddish brown) varying from merely a dot to 0.6cm in diameter with slightly raised edges, which may coalesce forming an irregular area. Often the small lesions are found in the ring along the leaf scars and then black resting bodies are seen on the decayed leaves and tunics. These spot on the corms are more or less circular and sunken but can be distinguished from scab since dry rot does not produce shining or gummy exudations. In moist storage conditions these black lesions run together to make the corms mummified but in dry season it is not so serious. The tunics of these infected corms look stuffy and turn brittle. This is a soil borne fungus and its longevity in soil has been found to be ten years or so.

**Management** : Corms can be cured by dipping them first in cold water for 24 hours and then for 30 minutes in hot water at 54.5 °C. Use of 0.1% potassium permanganate or 0.2% Bavistin for 20 minutes and spraying with copper solution twice or to thrice during the growing season at fortnightly intervals has been recommended. Dipping corms in dicloran (300g a.i./100kg corms in 100 litres of water) and spray in furrow before planting of corm is useful.

**Diseases of leaf and Flower**

*Botrytis* blight and flower rot (*Botrytis gladiolorum Timmermanns*)

**Symptoms** : It is destructive to leaves and flowers. Flower shippers sustain the greatest losses when flowers develop *Botrytis* rot after packing due to incipient infections. *Botrytis* survives in corms, soil and in plant debris. Disease epidemics erupt during the cool, wet weather conditions. Leaves of gladioli are most susceptible to infection after frost injury Sclerotia can be formed on all plants as well as on the corms. They have a dark color, are flat and of valuable size (1-9 mm), and employ part in spreading the disease in a flowering season under and above the ground they can produce spores, which are spread by the winds. The corm infections arise especially under too moist conditions during the storage of the corms. The other leaf infections manifest themselves after prolonged wet periods in which the crop remains moist too long. Such conditions especially prevail in a dense crop and in stuffy greenhouses. The lightest symptoms on the corm consist of little black-brown spots, which as a rule are found mainly at the top of the corm around the stalk base. Brown stains of variable shape and size may also occur on the surface. In case of severe infection, the corms become soft all over and reddish brown in color. Sometimes the outside shows white fungus threads (molds) and black Sclerotia. When the corms dry up, they will shrivel and become hard. The infections of the plant above the ground can occur at soil level, where the tissue is brown and rotted so that the plant becomes yellow and sometimes topple. The disease below ground tissue reveals large black sclerotia. Otherwise, the corm will be sound and well rooted. The symptoms on the leaves consist initially of light, afterwards dark brown round spots. Later in the season large and dead gray brown patches appear on the tissues, germinating spores may cause colorless watery spots on the flower.

**Management** : Keep the relative humidity low (maximum 80%) and maintain a good air circulation; Do not plant too densely; Remove clearly infected plants with their corms; When growing in greenhouses, ventilate well and if necessary, dry the crop by heating water in the
manner so that the crop will be dry before nightfall; Spray regularly from the time the crop comes up, during wet weather at least weekly 0.2 per cent; After harvesting the flowers, remove the remaining plants and corms as soon as possible. Effective fungicides: Vinclozolin, Iprodione, Benlate, Maneb and ferbam.

**Leaf Spots** (*Curvularia trifolii f. sp. gladioli* Parmela and Luttrell)

**Symptoms**: Brown oval spots on petals, young leaves with small clumps of black spores near center of larger spots are formed. This is also soil borne disease pathogen. It is destructive to cormel planting and may develop on flowers during warm humid weather. The disease attacks young leaves, survives in corms and in soil and is carried on seed. Infection from infested soil causes rot of leaves below soil. The disease acts as a "damping off" of young cormel and seed linked plants. Small plants may be killed without any sign of above ground infection.

**Management**: Maneb is effective in protecting leaves and stem against Botrytis, but open flowers and the bases of buds are not well protected. Maneb is less effective against *Curvularia* but is the best fungicide for both diseases (Maneb + Zinc ion formulations) are sold under various labels such as Manzate, 200 and Dithane M-45. Maneb’s spray should be applied 1-3 times per week, the number of applications depending upon the weather / season. As soon as the disease appears sprays should be applied every other day, especially during wet weather. Critical periods for infection with *Botrytis* are during cool weather after freeze or frost injury; the critical period for *Curvularia* disease is during warm weather. It is important to spray regularly before a freeze or frost occurs, whether *Botrytis* is present or not. Both diseases are more difficult to control after infections are established.

*Stemphylium* leaf spots (*Stemphylium* Wallr.)

**Symptoms**: The fungus attacks mature leaves of certain cultivars in cool and warm weather. Although leaf spots caused by this fungus may be mistaken for those caused by *Botrytis*, they may be distinguished by size. *Botrytis* spots very greatly in size, the smallest being visible only on the upper leaf surface. *Stemphylium* spots are usually more uniform and visible on both sides of the leaf.

**Management**: Spray of maneb or dyrene (0.2%) controls the disease.

**Leaf spots** (*Septoria gladioli* Pass.)

**Symptoms**: It is of minor importance and is easily controlled. Small, black spore bodies may be seen near the centers of older spots.

**Management**: Weekly spraying of maneb (0.2%) controls the disease.

**Bacterial**

**Bacterial leaf spots** (*Pseudomonas marginata, Xanthomonas germisudans*)

**Symptoms**: They may damage leaves in warm rainy weather. Plants that are crowded especially those from cormels are most affected. Spraying does not protect very well; sanitation is helpful in reducing spread of bacteria. Over head irrigation, use a fine spray to avoid the large
Heliothis armigera attack on carnations

Symptoms of *Botrytis gladiolorum* blight on spike and floral buds

Die back of roses
drops, which drive bacteria into leaf pores. Irrigate early in the morning before light causes the leaf pores or stomata to open.

Management: Cut flowers for use or breakout old flower heads only when foliage is dry, also avoid working among plants that are wet. If a cutting instrument is used, sterilize it frequently in 70% alcohol. Avoid use of excess N fertilizer; which results in lush growth. Corms to be dipped in Mercuric chloride (1:1000) before planting and storage.

Viral Diseases: Several viruses are known to infect gladiolus. Most of them are transmitted by aphids or nematodes. Aphids transmit mostly mosaic type viruses (for example, cucumber mosaic and bean yellow mosaic virus), whereas soil-living microorganisms the ringspot viruses (for example, tobacco ringspot and tomato ringspot virus). Aster yellows is reported to be transmitted by leaf hoppers.

Management: Use of virus-free planting material is required to raise healthy plants. Meristem tip culture is known to eliminate most viruses from infected plants and hence of value where whole of the planting stock is infected. Healthy planting stock must be maintained under insect-proof structures or by controlling insect vectors with suitable insecticides. Genetic resistance of the host to the major viruses is a long-term approach to the problem.

Non parasitic disease symptoms are caused by unfavorable weather conditions, faulty nutrition, injurious chemicals and polluted air. A bud sheath burn or crooked stems may result when the young spike is under a water stress and wilting. Wilting exposes the young bud sheaths to the sun and wind, causing brown tips. Older leaves exposed directly to the sunlight may have small rusty brown spots due to the action of the sun, on water drops over a film of spray chemicals. The bright morning sunlight causes yellow horizontal bands on young leaves and on the short sheathing leaves. This occurs most often on moderately cool mornings on newly exposed leaf tissues near the soil surface. The bends often indicate the daily growth of the leaves. The yellow tissue gradually turns green in most cases. Holding the cut flowers in water containing one or more parts per million of fluorides causes break down and discoloration of petal edges. The mineral content of some well waters may also injure the florets. Petal edges may also be injured by dusts of certain chlorinated hydrocarbon pesticides applied to buds just before openings. Physiological flower bud rot and topple of the flower heads were found to be caused by calcium deficiency. Leaves and flowers may be injured by spray chemical herbicides and air pollution. Gladioli are extremely sensitive to certain fluorine compounds whether present in the air oil or dusted on plants. Fluorinated drinking water contains enough fluoride to damage florets opened from tight bud on cut spikes. The insecticides Cryolite or Kryolide, is a fluoride, which causes severe leaf, tip burn and scorch when sprayed or dusted on gladiolus. Phosphate fertilizers normally contains fluoride and when applied to acid soils (below pH5) the fluorides may be absorbed by the roots and cause a sleeve leaf scorch. Other factors causing leaf tip burn include roots injurious due to flooding, excessive fertilizers and nematodes.

Tip Burn: It is believed that it occurs due to high levels of aerial fluorides in the atmosphere.

Symptoms: This physiological disorder results in discoloration and drying up of tips of leaves of gladiolus. Some of the saprophytic fungi also start invading the necrotized tissue.
Management: It is recommended that a spray of Blitox 50 WP (0.3%) should be given at initiation of symptoms and repeated once more if required. There is not much to worry about this malady, as it does not cause a serious economic loss to the grower.

Insects and Other Animal Pests

Aphids (Aphis gossypii, Myzus persici, Dysaphis tulipae etc.)

Symptoms: This is one of the commonest of the plant lice that attack gladioli in the hot months of summer. There are two kinds of females: (a) The wingless aphid varies from pale yellow to very dark green and produces young aphids; this is the form that is seen on the gladiolus plant. (b) The winged female is more slender and the greater part of the head and thorax are dark colored. These are seldom seen on plants, but their former presence is indicated by the jet-black, shining oval eggs that they have deposited. This insect should be controlled, especially since it is the carrier of the mosaic virus. The potato aphid, Macrosiphum euphorbiae, also infests the leaves of gladioli.

Management: Spray with Sevin, Meta-Systox R, or Malathion (0.2%) as soon as aphids appear on the leaves. Repeat the application in 2 weeks, if necessary.

Thrips (Taeniothrips simplex)

Symptoms: Four species of thrips infest gladioli: gladiolus, banded greenhouse, greenhouse, and western flower. Leaves and flowers of gladioli and related plants show characteristic light flecking where thrips have fed. Infested surfaces are of an unnatural glistening whitish-gray color, because the cells in drying out become filled with air and so reflect the light. The young thrips are light yellow in color and move about irregularly when disturbed. They feed under the leaf sheaths and appear mostly in cloudy weather, seldom in bright sunlight. The older thrips, about 1/16 inch long, are black with lighter markings on the wings. The wings have layers of hairs, which are arranged like the parts of a feather. Each female insect lays about 200 eggs in slits on the surface of a plant. Brown spots on the dead tissue show where the eggs were laid. Young thrips are found under the sheathes; they may surround the stems in great numbers. Infested flowers are discolored and spotted; they dry up and shrivel as though burned. Infested spikes often fail to bloom. The foliage of infested plants has many whitish spots that make the surface appear light. Later the leaves turn brown and dry out. Infested corms are often sticky from the sap that oozes out as a result of injury by thrips. They are darker in color than normal corms and their surface tends to become rough. Badly infested corms develop such weak root systems, that the plant forms small flowers and leaves, if any. From 2 to 4 weeks are required for the thrips to reach maturity, so there may be as many as five or six generations maturing during the summer. In northern areas the thrips hibernate on the corms in storage, but in warmer climates they may winter in corms or parts left in the ground through oversight.

Management: Spray with Diazinon, Cygon, methoxychlor, or Sevin during the early part of the growing season. These materials should be used before flowers are formed because they may damage the delicate petals. Water will also help to control thrips. Storage of corms at lower temperatures (5-7°C) is also effective.
Borers (*Helicoverpa* (=*Heliothis armigera*)

**Symptoms**: The larvae of *Helicoverpa* are given in colour with dark brown, grey lines along the sides of their body. They are polyphagous in nature. They feed on leaves and unopened florets. They also bore into the seed capsules and damage the seed.

**Management**: They may be controlled by spray applications of Thiodan 35 EC (0.5-0.8%). Spraying should be done at first instance of the larvae if effective control of this insect pest has to be achieved.

Loopers and Semiloopers (*Trichoplusiani, Pieris brassicae*, etc.): These insects feed primarily on leaves of gladiolus. Control measures are the same as for *Helicoverpa* except that a lower dose of the insecticides (0.5%) has to be employed. Nuvan (0.1-0.2%) may also be used.

Root-knot nematodes: Nematode species, *Meloidogyne incognita* and *M.hapla* are known to invade roots of gladiolus. The infestation of the nematode is particularly high in sandy soils under warm weather conditions.

**Symptoms**: The affected plants show retarded growth and turn pale in colour. The characteristic symptom is formation of galls on roots of the plant.

**Management**: It is advised that Thimet 10 G or Temik 10 G at the rate of 12 Kg of granules per acre should be worked into the soil. Hot water treatment of dormant corms at 53°C effective in eliminating the nematode. Flooding of soil has also been found effective in eliminating the nematode. Some of the crops such as tomato, eggplant and okra are highly susceptible to *Meloidogyne* spp., hence, their cultivation should be avoided in areas where gladiolus is to be grown. Treatment of corms with biological formulations of *Trichoderma* also help in managing nematodes.

**CHRYSANTHEMUM**

**Diseases — Fungal**

**Basal stem rots (*Pythium* and *Rhizoctonia* spp.):**

**Symptoms**: Rotting of cuttings in rooting beds is most common and serious and the fungus may also enter the established plants through the wounds caused by pinching etc. Sudden wilting of infected parts is the main feature. High humidity and temperature periods account to this disease.

**Rhizoctonia**: May be distinguished by the following;

- a) The decay originates near the soil surface rather than in the root system.
- b) The diseased area has a brown coloration
- c) Strands of brownish mycelium can be seen with a hand lens.
- d) Where plants are crowded, such as in a propagating bed or container, the fungus can form a brown coloured web over the plants.
e) The expression of the disease is often rapid and rots mature plants upward from an infection at soil line.

**Pythium**: May be distinguished by the following symptoms:

a) Rotting may start at the root tips.

b) Does not produce a characteristic color, roots will be brown and black depending on the stage of decomposition. Rapid blackening of stem on actively growing plants is not uncommon.

c) May destroy the root system. Causing a slow retardation in growth.

d) In almost all cases the root system has stood in water at some time. Field observation reveals both *Pythium* and *Rhizoctonia* attacking the plant at the same time. Spread of the organisms is through the transfer of plants, tools and soils. Next to the poor soil aeration and inadequate drainage, high salt concentrations are known to predispose the plants to infection and increase the severity of the disease expression. The most severe symptoms of the disease are usually found on the beds having an uneven soil surface permitting surface water pockets. Under cover the greatest incidence will be observed in that part of ground bed where surface runoff flooding was permitted. In both the cases the excess of water seals the soil and provides conditions favorable for both the diseases.

**Management**: Preplanting sterilization of soil with Formalin (0.2%) and regular drenching with Thiram controls the spread of infection to neighboring cuttings.

**Phoma root rot** (*Phoma spp.*)

**Symptoms**: The disease is first noticed on lower leaves, which show chlorosis and later wilt, and then spreads upwards.

**Management**: Pre-planting soil drench with nabam (1.5 g/l) gives excellent control.

**Stem rot and wilt**: (*Fusarium oxysporum* Schlechtend ex. Fr.)

**Symptoms**: Disease develops only after the appearance of flower buds although infection might have occurred even in rooting beds. Stem near soil becomes dark brown and dries. Lower leaves turn yellow and plant wilt permanently afterwards.

**Management**: Soil application of Dithane M-45 (0.2%) controls the disease.

**Grey mould** (*Botrytis cineria* Pers. Ex. Fr.)

**Symptoms**: The fungus can attack the plant at any stage from rooting bed to flowers in transit. First girdling of stem takes place that results in death of upper part. Leaf infection starts from margin and proceeds towards center and base showing semi-circular bands. Flower infection starts with brown water soaked spots on lower petals.

**Management**: Good aeration, more planting distance and spraying with captaf (1 g/l) or thiram (3 g/l) provides good control.
**Septoria leaf spot:** *(Septoria obesa Sacc and S. chrysanthemella Sacc.)*

**Symptoms:** Most common and serious disease produces brown spots on leaves that grow in size and number in humid conditions. Leaves turn yellow and die afterwards. Of the 38 chrysanthem cultivars assessed for their disease reaction under field condition, the cultivars, “Alandi Local”, “Varsha”, “Mohini”, “Harvest House”, “Sarad Shobha”, “Meera” and “Kirti” were found resistant, while local cv “Zipri” was most susceptible (MPKV, Pune).

**Management:**

Control measures include picking and destroying leaves, providing dry and airy environment and spraying bavistin 0.1%. MPKV, Pune and PAU, Ludhiana had reported that Dithane M-45 (0.2%) six sprays to be given at 15 days interval starting from 1st incidence of disease was effective. A new leaf spot of chrysanthem caused by *Phoma chrysanthemicola* has been reported at Ludhiana in severe form under field condition (PAU). For the control of leaf spot disease of chrysanthemum, it was also recommended to spray the crop with 0.2% copperoxychloride or 0.2% Mancozeb with sticker seven time at an interval of 10 days during June to October (MPKV, Pune).

**Chrysanthemum Ray Blight** *(Didymella chrysanthemi)*

**Symptoms:** It affects all above ground parts but is most severe on the shoots and on the flowers which develop reddish petal spots on light coloured cultivars and brownish spots on darker coloured types. The lesions spread rapidly and the flowers collapse with the ensuing decay. On shoots the disease often begins with the rotting of terminal buds while the leaves are affected by patches of brown black decay. When large lesions form at the base of the stem, the plants may develop small, yellow and often shrivelled leaves.

**Management:** Destroy diseased plants promptly and avoid high humidity in greenhouses. Spray at least three times at weekly intervals with zineb or thiram (0.2%) following the appearance of symptoms. Where the disease is suspected or prevalent, dip unrooted cuttings in benomyl suspension. The incidence of blight disease of chrysanthemum was low (5.83%) under polyhouse condition than under open field condition (38.4%) reported from MPKV, Pune.

**Powdery mildew** *(Erysiphe cichoracearum DC)*

**Symptoms:** White powdery patches appear on the upper surface and tender shoots.

**Management:** Keeping dry environment and spraying with carbendazim (0.1%) controls the disease.

**Rust** *(Puccinia chrysanthemi Roze)*

**Symptoms:** The pustules appear as blister like swellings, which break open releasing masses of powdery uredospores. Severely infected plants are stunted and do not bloom properly.

**Management:** Steam sterilization of soil and pots, to keep humidity below 75%, cutting and burning infested plants and spray of mancozeb are some of the control measures.
Verticillium wilt (V. albo-atrum Reinke and berth and V. dahliae Kleb.)

Symptoms: Symptoms appear at the flower bed initiation and the plants wilt suddenly.

Management: Selection of healthy stock plants, soil sterilization and spraying with bavistin have been recommended for preventing its spread.

Ray specks (Erwinia chrysanthemi.)

Symptoms: Wilting of one or more branches during sunny day and recovery at night is an initial symptom. Later on stem tips turn brown, brittle and collapse. Stem becomes hollow with brownish streaks extending up to base. Cuttings either remain stunted or die.

Management: Soil sterilization, using disease free cuttings and avoiding contamination during pinching are some of the precautions and use of streptomycin in rooting beds is advised to control it.

Bacterial leaf spot

Symptoms: Circular elliptical leaf spots appear, increase and coalesce to form large necrotic areas. The disease appears first on basal leaves and progresses upward to flower buds, which turn dark and die later.

Management: Use of disease free cuttings and spraying in rainy season with copper sulphate controls the problem.

Viral diseases: As many as 20 viral diseases are reported on this crop. In all the stunted plant, curling of leaves and rosette formation on terminal growth is the main symptoms. Thrips and aphids etc. transmits the virus so they should be controlled in time.

Chrysanthemum stunt (Chrysanthemum Stunt Virus)

Symptoms: Overall reduction in plant size. Pale foliage with margins failing to enlarge giving stiff appearance. Red and bronze flowers, often bleached, may open prematurely.

Management: As the virus is transmitted through the wounds the tools used to cut or pinch affected plants should not be used on healthy plants without proper sterilization. Use cuttings from healthy plants.

Insects and Other Pests

Aphids (Aphis helichrysi, Myzus persicae, Macrosiphum sanborni)

Symptoms: The following kinds of aphids infest chrysanthemums: chrysanthemum, foxglove, green peach, leaf-curl plum, melon, myrtle, and thistle. One of the most common, the chrysanthemum aphid Macrosiphoniella sanborni, is large, dark chocolate brown. It clusters on tender terminal shoots and on the underside of the leaves resulting in stunting, leaf curling, and sometimes the death of the entire plant.

Management: All species of aphids are easily controlled with Malathion or Metasystox sprays (0.2%). Biological control of chrysanthemum aphids has been developed on commercial crops.
by rearing small parasitic hymenopterans, *Aphidius matricariae*, for release on cuttings before distribution. This ensures that the parasite will be present on young plants and will help to eliminate aphids that may have survived chemical treatments. This technique could be used in gardens but require scientific expertise.

**Beetles**

**Symptoms**: Among the various kinds of beetles which feed on this host are the following: Asiatic garden, blister, Fuller rose, goldsmith, rose chafer, and spotted cucumber.

**Management**: Spray with Sevin (0.2%).

**Bugs**

**Symptoms**: Many kinds of bugs attack chrysanthemums. Among the most common are the four-lined plant, harlequin, lygus, and the tarnished plant. The last, *Lygus lineolaris*, attacks stems just below the bud, causing wilt.

**Management**: Malathion or methoxychlor sprays applied as necessary will control most bugs.

**Caterpillars**

**Symptoms**: Yellow woollybear and zebra caterpillars chew the leaves of this host.

**Management**: Spray with *Bacillus thuringiensis* or Sevin when the caterpillars are small.

**Chrysanthemum Gall Midge** (*Diarthronomyia chrysanthemi*)

**Symptoms**: This midge is primarily a pest of greenhouse chrysanthemums and is little known on garden plants. The fly lays eggs in masses on the surface of new foliage; this foliage is covered with hairs which protect the eggs. The eggs hatch in 3 or 4 days, and the larvae soon enter the leaf, where they stimulate the formation of small, pimple-like galls, familiar to all growers of these plants. The infested foliage is much distorted and unsuitable for the market.

**Management**: Diazinon or methoxychlor sprays are effective against the gall midge.

**Chrysanthemum Leaf Miner** (*Phytomyza syngenesiae*).

**Symptoms**: The leaf miner feeds on the inner tissues of the leaf just under the epidermis, making irregular tunnels especially near the margins.

**Management**: Spray with Diazinon to kill the insects just beneath the epidermis. Repeat 2 weeks later if necessary.

**Greenhouse Leaf Tier** (*Udea rubigalis*)

**Symptoms**: These caterpillars feed on the more tender tissues of the underside of the leaves, avoiding the veins.

**Management**: Handpicking is useful if the plants are not too numerous; otherwise they can be sprayed with Sevin.
Chrysanthemum Lace Bug (*Corythucha marmorata*)

**Symptoms**: The adult stage of this pest has lace-like wings. Both the young and adult stages suck out leaf juices, causing bleaching of the leaves and injury to the stems.

**Management**: Spray with malathion, Diazinon or Sevin directing the material mainly to the lower leaf surfaces.

Mealybugs

**Symptoms**: Among the mealybugs which infest chrysanthemums are the citrus, ground, greenhouse, and the Mexican. The last, known scientifically as *Phenacoccus gossypii*, is primarily a pest of greenhouse chrysanthemums.

**Management**: Ants, which are large responsible for the spread of these insects, can be eradicated by dusting or spraying the soil surface lightly with Diazinon or Dursban. Sprays may also be applied directly to the mealybug-infested plants. Malathion sprays are also effective.

Thrips (*Thrips tabaci, T. nigrophilosus, Franklinilla tritici, Hercirothrips*)

**Symptoms**: Three species of thrips, the banded greenhouse, the chrysnathemum, and the greenhouse, attack chrysanthemums. They cause flecking or silvering of the leaves of greenhouse-grown plants.

**Management**: Spray with Sevin.

Mites

**Symptoms**: Three species of mites infest chrysanthemums: broad, cyclamin, and two spotted. Broad and cyclamen mites are discussed under Cyclamin. The two-spotted mite, *Tetranychus urticae*, causes distorted foliage and shriveled, discolored blooms. They are red dot like bodies on undersurface of leaves causing white specks in the early stages. They occur in hot season and damage leaves and buds which give pale appearance.

**Management**: Spray with Cygon, Meta-Systox R, or Kelthane from time to time as needed.

Hairy Caterpillars

**Symptoms**: It (*Diacrisia obliqua*) attacks the plants in rainy season and continues till winter. The pest is easily recognized by the presence of hair on their body. They multiply fast and have gregarious habit during early stage. As they eat up the leaves from surface, papery skeletons are left which dry up. Manual collection and destruction in early stages can check heavy infestation.

**Management**: Spraying thiodon 35 EC or ecaulux 35 EC at 1.25 ml/l is recommended as a control measure.

Grubs

**Symptoms**: Grub (*Holtorichia sp.*) is a troublesome pest, which remains underground, particularly in shade under the trees. It cuts the underground portion of stem or roots causing sudden wilting of healthy plants during dry hot months.
Management: Soil application of aldrin, lindane or thimet has been found effective against the grub.

Foliar Nematode (Aphelenchoides ritzema basi).

Symptoms: This nematode has long been known to be a pest of greenhouse chrysanthemums, but only in recent years have they become very injurious to hardy chrysanthemums grown outdoors. When the stems are wet, the worms swim up through the film of water and enter the stomata of the leaves. The first symptom of infection is a yellowish-brown spotting of the leaves. The spots are more or less bounded by the larger veins; they enlarge and run together so that the entire leaf is involved. The leaves die, become brittle, and fall. The symptoms may be confused with the leaf spot disease caused by the fungus Septoria, but the spots caused by eelworms are brownish and not black. The worms also infest the ray flowers and prevent proper development of them. Seriously infested plants die without developing much good foliage or blooms.

Control: Several precautions must be observed in controlling these pests on garden chrysanthemums. First, propagate only by taking cuttings from the tops of long, vigorous shoots. Do not propagate by dividing an old clump. Avoid replanting chrysanthemums in the same area year after year. As soon as the soil has warmed, much the surface with peat moss or some other material. This helps to prevent infection of the lower leaves by nematodes that may have survived in old, infested leaves. Aldicarb (500 g/ha) has been found effective against this nematode. The root-knot nematodes Meloidogyne incognita and M.hapla infest the roots of chrysanthemums.

Combination Spray for Chrysanthemums: The following combination spray will control all the more prevalent fungus diseases and insect pests of outdoor chrysanthemums:

- Sevin, 50% wettable powder 2 Tablespoonfuls
- Malathion, 25% WP 4 Tablespoonfuls
- Zineb, 65% WP 1 Tablespoonful
- Kelthane, 35% WP 1 ½ teaspoonfuls
- Water 4 litres

Mix the four ingredients dry, then add enough water to make a very thin paste. Pour this mixture into the spray tank, preferably through a fine screen or cheesecloth, add water, and stir.

Biological Control: Chrysanthemum is largely damaged by the pests like aphids, leaf eating caterpillars of moths and butterflies etc. Moths and butterflies lay their eggs on leaves and newly emerging buds causing irreparable damage. The insecticides sprayed on the plants fail to kill them. The growth of plant is also greatly affected by environmental pollutions like toxic gases, smoke, heavy dewdrops, smog, dirt etc. It is not practicable to spray chemicals and insecticides directly on flower and buds. Use transluscent paper bags or polythene bags to cover the buds and flowers. It protects the buds and flowers from moths and butterflies and does not allow them to lay eggs on them. It also saves the buds and flowers from dirt, dust, smoke, dew, toxic gases and other sources of pollution.
CARNATION

Diseases — Fungal

Wilt (Fusarium oxysporum f. sp. dianthi (Beach) Snyder & Hansen)

Symptoms: This disease is one of the major problems in carnations causing losses to the commercial growers. It is favored by warm temperature and can cause very high percentage of mortality. Chief diagnostic symptoms are abnormal growth and stunting of young shoots. Leaves become yellowish and the stems are soft so as to be easily crushed. The entire plant wilts and collapses in short time after the attack. The part of the stem in contact with soil shows shredding of bark while wood beneath remains firm. If pulled the plant breaks off easily. Fusarium wilts are very difficult to manage. The fact that even a single infection of a plant by one spore is sufficient to introduce the pathogen into the plant in which it then grows and spreads internally and makes prevention of infection and subsequent control with surface fungicides practically impossible. Also, Fusarium sp. can survive in the soil for long time and this makes control through crop rotation and other cultural practices ineffective. Management practices of Fusarium wilt in ornamental crops include many factors, which though not successful in completely eliminating the pathogen but are helpful in reducing the pathogen population and disease severity. A complete disease management programme against Fusarium wilts is based on

(a) Pathogen free stock;
(b) Soil free of pathogen
(c) Sanitation.

Pathogen free stock: For vegetatively propagated ornamental crops, the use of clean, pathogen free propagules (cutting, divisions, runners, corms, bulbs, buds, and grafts) is of utmost importance. Since the Fusarium pathogen occurs in the vascular elements and may be already infected when removed from parent. Clean vegetative propagules can be obtained through the cultured cuttings, apical meristems, single cell cultures and indexing procedures.

Pathogen-free soil: The population of pathogen in the soil can be reduced by

(i) Clean cultivation - direct destruction of crop refuses, debris and infested plant material,
(ii) Soil treatment with fumigants,
(iii) Pasteurizing the soil with steam and
(iv) In specific climatic condition by soil solarization.

Sanitation:

Soil treatment with fumigants: Soil fumigation can greatly alleviate disease losses. Methyl bromide, chloropicrin, a mixture of both vapam, etc. are general fungicides used for fumigation of nurseries or in high profit crops like green house ornamentals and vegetables. Ethylene dibromide (EDB) and DD mixture control nematodes while predispose crops to the wilt fungi. Carnations are generally grown as monocultures, sometimes consecutively for more than 15 years. Fumigation with Methyl bromide (800 kg/ha) has become a common practice to reduce the initial inoculum of F. oxysporum f.sp. dianthi. This treatment however does not completely eradicate the pathogen from fumigated soils, especially in deeper layers.
Steam sterilization: In glasshouse cultures of intensively grown crops such as carnations, soil sterilization by steam pasteurization is a standard practice to eliminate inoculum before planting, to prevent Fusarium as well as other diseases due to soil borne pathogens.

Management: This disease can also be prevented by drenching of soil around the plants base with carbendazim (0.1%) or Bavistin (0.15%). Spraying of plants with Dithane M-45 (0.1%) + Bavistin (0.1%) at fortnightly interval was also reported to be effective. From MPKV, Pune it was reported that out of the 7 cultivars of carnation, "Sims Pride", "Scanna" and Arthur Sim were found tolerant to wilt disease.

*Alternaria* leaf spot and blight (*Alternaria dianthi* Stevens and Hall)

**Symptoms:** This is the most common and serious foliar disease of carnations. Small and purple coloured spots appear on the leaves. Under moist conditions these enlarge to form leaf spots upto one cm in diameter. The margins of the lesions are usually purple in colour and centre grey-brown and black spores may be present in this area. Several spots may merge resulting in the death of the leaf. The pathogen also causes basal rot of cuttings. This fungus also affects the stems, usually at the nodes where it enters through the wounds or growth cracks producing black lesions.

**Management:** Destruction of diseased debris and Dithane M-45 (0.2%) spraying are recommended. It was recommended from AICRP centre, that fungicide like Blitox (0.3%), Foltaf (0.2%), Captaf (0.3%) and Indofil M-45 (0.2%) were effective to reduce the leaf spot infection in a significant manner.

*Rhizoctonia* stem rot: This disease is caused by *Rhizoctonia solani* and affects the plants at the soil line and they die within a week or so. Grow the crop in raised beds treated with 0.5% formaline. Drench the infected plants either with carbendazim 0.1% or thiram 0.2% or Dithane M-45 0.2%.

*Grey mould:* *Botrytis cinerea* is the most common fungus in carnation production. The biggest problem is often the attack on the flowers. In the greenhouse, it happens when there is high humidity. Reduce the humidity.

**Viral diseases:** Carnations are subjected to many viral diseases, the most common ones being streak, mosaic, mottle, ring spot, etched ring and vein mottle. Use virus free planting material raised through shoot tip culture.

Insects and Other Pests

*Variegated Cutworm* (*Peridroma saucia*).

**Symptoms:** This cutworm feeds on a number of greenhouse and garden plants. The eggs, 50 or more, are laid on the stems or on the undersides of leaves by adult moths. The full-grown caterpillar is about 2 inches long. It climbs the stems of carnations and feeds on the buds, often cutting off the stem just below. Young plants are often cut off at the surface of the ground. The worm is most prevalent in fields during June and July.
Management: Apply Diazinon to the soil prior to planting, or spray the plants with Sevin when they are set.

Green Peach Aphid (*Myzus persicae*): This aphid, which spreads several carnation viruses, can easily be controlled with Malathion or Sevin sprays (0.2%).

Caterpillars: The oblique-banded leaf roller and the greenhouse leaf tier also infest carnations. These are easily controlled by early applications of *Bacillus thuringiensis* or Sevin. Regular spray of Ripcorb (0.1%), Endosulfan (0.05%) or polyfrin (0.1%) at fortnightly interval are also recommended for control of caterpillars.

Thrips (*Thrips tabaci*): Onion thrips do some damage to carnations in greenhouses and in the fields.

Management: Severe thrips attacks on greenhouse and houseplants are often associated with poor growing conditions resulting from underwaterting and overheating. Regular watering and maintenance of a cooler, humid atmosphere can therefore help to prevent infestations. Similarly, infestations on outdoor plants are usually worst during hot dry periods and thrips populations are reduced in cool, wet weather. Most thrips are easily controlled with contact insecticides. Spray of Rogor (0.1%) is recommended.

Glass House Red Spider Mite (*Tetranychus urticae*)

Symptoms: Leaves turn pale and have a dusty coating and fine webs, and the plant is stunted when heavily infested with these tiny pests. Leaves usually become progressively, often showing characteristic bronzing, and in severe attacks the leaves may wither and die.

Management: In the greenhouse this pest is best controlled with miticide aerosols. On outdoor plants, chlorobenzilate, Kelthane, Meta-Systox R, or Tedion sprays are effective. Spray of Malathion or Metacid (0.1%) or Dicofol (0.2%) at fortnightly interval was reported to be effective.

Nematodes — Southern Root-Knot Nema (*Meloidogyne incognita*)

Symptoms: This nematode occasionally infests the roots of carnations.

Management: Sanitization of the field. Fumigation with nematicide.

ORCHID

Diseases — Fungal: Leaf Spots (*Gloeosporium, Colletotrichum, Phylllosticta and Phomopsis* spp.)

Symptoms: This disease is very common and can be found on almost all cultivated species of orchids. It is caused by species of *Gloeosporium, Colletotrichum, Phylllosticta and Phomopsis*. Within a few days of infection, sunken spots appear at any place on the leaves that later turn brown. Most leaf spot organisms do not kill the leaves but formation of spot make the leaves unsightly. Warm humid weather and lack of light encourage the spread of disease.

Management: Spraying of Bordeaux mixture (6-6-50 or 4-4-50) will effectively control the disease. Blitox (0.3%), or Difolotan (0.1%), or Bavistin (0.1%) may be sprayed as a remedial measure.
**Pythium Black Rot** (*Pythium ultimum* (Trow) var. *ultimum*)

**Symptoms**: This disease affects mostly seedlings in community pots. Affected plants turn black and leaves start falling. The pseudobulbs also start to rot within. Since in community pots the plants are close to each other, the disease spreads from plant to plant at a very rapid rate. Orchids such as *Cattleya* and *Epidendrum species* are found to be highly susceptible to damping off.

**Management**: Withholding of watering for a few days and shifting the plants to less humid part of greenhouse help to check the disease. Removal of infected plants and spraying with mancozeb @ 2g/l can effectively control the disease.

**Flower blight** (*Botrytis cinerea* Pers.(Ex) Fr.)

**Symptoms**: This disease is serious on orchids like *Cattleya*, *Dendrobium*, *Phalaenopsis*, *Oncidium* and *Vanda* under cool, damp and still conditions. It produces numerous, small, dark brown spots on petals especially of older flowers. *Botrytis* sporulates heavily on dead and diseased flowers.

**Management**: Removal of the infected parts and proper sanitation is the most important management practice. Spray of following fungicides viz., Benomyl, Bavistin (0.1%) or Dithane M-45 (0.2%) at regular intervals are recommended.

**Bacterial — Bacterial Soft Rot**

**Symptoms**: The disease is caused by *Erwinia carotovora* in *Cattleya* orchids. The disease starts at the upper end of the leaf as a small water-soaked and somewhat darker than normal green spot. Pseudobulbs turn soft and pulpy and become yellow in colour.

**Management**: Streptocycline (0.01%) treatment was reported to be effective.

**Viral — Blossom brown necrotic streak**

**Symptoms**: It attacks *Cattleya* species and produces brown spots, or whole flower break, yellow streaks on leaves. It is transmitted from one plant to another through the cutting knife.

**Mosaic flower break of Cattleya and other orchids**

**Symptoms**: It appears either as a mild colour break with flower variegation but no distortion, or as a severe colour break with flower distortion and variegation. Leaves are mottled and sometimes twisted. Transmission is by green-peach aphid *Myzus persicae*

**Cymbidium-mosaic, black streak or Cattleya leaf necrosis**

**Symptoms**: On cymbidium it first produced mosaic mottle then necrotic spots, streaks and rings on leaves. In *Cattleya*, sunken brown to black leaf patterns appear; sometimes rings, more often elongated streaks are formed on the older leaves. If leaves are killed premature, few small flowers of normal form and colour are formed.
Odontoglossum ring-spot

**Symptoms**: Small necrotic spots and rings develop on the older leaves and light green to yellow areas develops on the younger leaves. The leaves may turn yellow and drop in 2 to 3 months. No flower symptoms develop. No vector has been identified.

**Management**: Using a hot or a disinfected knife while dividing the plants, sterilizing or fumigating the potting medium, using disease free planting material and spraying periodically with insecticides help prevent disease spread. Infected plants may be removed from the orchid house. Tissue culture proved to be effective in rescuing valuable clonal orchids infected with virus. But it is not applicable for all orchids and all viruses. Meristem culture is one of the ways of getting rid of the virus in Cymbidium orchids.

Insects and other Animal Pests

**Aphids** (*Cerataphis orchidearum* and *Neomyzus circumflexus*).

**Symptoms**: The orchid and crescent-marked lily aphids infest orchids.

**Management**: Spray with malathion or Sevin (0.2 %).

**Orchid Weevil** (*Diorymerellus laevimargo*).

**Symptoms**: Wherever orchids are grown, this weevil usually becomes known to the grower. The adult is about 1/8 inch long, shining, black and smooth. The larva is a white, legless grub about 1/16 inch long when fullgrown. If feeds on the new roots, hollowing out the inside and causing the tips to turn black. The adult beetles feed to some extent on the roots, but they cause much injury to young, tender leaves, to the sheaths surroundings the flower buds, and to bulbs. They also feed on the petals before the flowers open; they make irregular holes through which fungi and bacteria enter to cause blossom decay.

**Management**: Spray plant with methoxychlor (0.2 %).

**Orchid bulb Borer** (*Metamasius graphiperus*).

**Symptoms**: The blackish adults are slightly over ½ inch in length, with large palé yellowish blotches on the wing covers. They feed on the leaves and other parts of the plant. The larvae feed inside the bulb, and so open the way to fungus rots.

**Management**: Spray with methoxychlor (0.2% ).

**Orchid Fly** (*Eurytoma ochidearum*).

**Symptoms**: It is a small black wasp-like fly, 1/8 inch long. Its eggs are deposited at the bases of the pseudobulbs, or sometimes on young leaves and rhizomes. The eggs hatch within a week or two; the maggots feed at first in separate galleries: After the flies have emerged, the buds turn brown or black and no flower appears.

**Management**: Reject all suspected plants or isolate them and make frequent inspections, cutting out and destroying the whole shoot rather than merely the infested part. Good control has
been obtained by cutting out and discarding the swollen areas on the pseudobulbs, and by spraying with methoxychlor (0.2%) to kill the flies.

**Orchid Mealybug** (*Pseudococcus microcirculans, Feressia virgata*)

**Symptoms**: These pest suck sap secrete honey dew and attract ant. With serious infestation sooty mould may develop on the leaves.

**Management**: Spray with Cygon, Diazinon, Meta-Systox R, or Malathion are suggested. Application of metasystox (2ml/l) or demecron (0.5 ml/l) were found effective against the pests.

**Cattleya Midge** (*Parallelilodiplosis cattleyae)*

**Symptoms**: The yellowish maggots, 1/8 inch in length, feed in the tip ends of young roots of various kinds of orchids, causing them to form unsightly nut-like galls.

**Management**: Cut off and destroy the galls. Repot the plants and spray with methoxychlor (0.2%) when the midges come out.

**Cattleya Weevil** (*Cholus cattleyae)*

**Symptoms**: The adult weevils are somewhat less than ½ inch in length, and have white marks on the back. They injure the pseudobulbs by feeding on the surface and they will also puncture the leaves. The larvae feed on the leaves and develop on stems and pseudobulbs. This opens the way for decay and results in the failure of plants to bear flowers.

**Management**: Spray with methoxychlor (0.2 %).

**Dendrobium Borer** (*Xyleborus morigerus*)

**Symptoms**: Minute brown beetles bore into the pseudobulbs and deposit many eggs in brood galleries. The larvae infeeding make rather long galleries. Badly infested bulbs wither and die.

**Management**: Cut out and destroy infested bulbs as soon as they are detected. Spray plants with methoxychlor (0.2%).

**Orchid Plant Bug** (*Tenthecoris bicolor)*

**Symptoms**: The mature insects vary from orange to bright red, with a black design down the back. The wing covers are steel blue. Irregular white spots on the undersides of leaves are a result of the feeding of both adults and young.

**Management**: Withholding of watering for a few days and shifting the plants to less humid part of greenhouse help to check the disease. Removal of infected plants and spraying with mancozeb @ 2g/l can effectively control the disease.

**Cattleya Midge** (*Parallelilodiplosis cattleyae)*

**Symptoms**: The yellowish maggots, 1/8 inch in length, feed in the tip ends of young roots of various kinds of orchids, causing them to form unsightly nut-like galls.
Management: Cut off and destroy the galls. Repot the plants and spray with methoxychlor (0.2%) when the midges come out.

Catteya Weevil (Cholus cattleyae).

Symptoms: The adult weevils are somewhat less than ½ inch in length, and have white marks on the back. They injure the pseudobulbs by feeding on the surface and they will also puncture the leaves. The larvae feed on the leaves and develop on stems and pseudobulbs. This opens the way for decay and results in the failure of plants to bear flowers.

Management: Spray with methoxychlor.

Dendrobium Borer (Xyleborus morigerus).

Symptoms: Minute brown beetles bore into the pseudobulbs and deposit many eggs in brood galleries. The larvae infeeding make rather long galleries. Badly infested bulbs wither and die.

Management: Cut out and destroy infested bulbs as soon as they are detected. Spray plants with methoxychlor (0.2%).

Scales (Aspediotus destractor, Coccus hesperidum and Lecamium formcarii)

Symptoms: They attack themselves to the leaves and sucks the juice from the cells.

Management: Malathion and Sevin are effective against scales particularly the crawler stage. Spray of fenitrothion (1 ml/l), metasystox (2 ml/l) or metacid (2 ml/l) were found effective in controlling the pests.

Thrips

Symptoms: Several species of thrips by their rasping and sucking cause a browning or blotching of the leaves and a blasting of the buds. The symptoms are the familiar light gray discolorations and silvery appearance of the leaves and flower surfaces and finally a brown discoloration. Cattleya especially may be severely injured by the minute yellowish nymphs of Chaetanaphorthrips orchidii. The greenhouse thrips, Heliothrips haemorrhoidalis and Hercinothrips femoralis, are not uncommon on orchids.

Management: Commercial growers of orchids resort to Sulfotepp, which is dangerous to handle. Spray of malathion (2ml/l) or metasystox (2ml/l) were found to be effective for controlling the pests.

Mites (Tetranychus urticae)

Symptoms: These insects suck juice from leaf cells, leaving them speckles with white. In heavy infestations, webbing appear on the plants. The Oncidium mite is a serious pest of Oncidium and Odontoglossum.

Management: The mite infestation can be controlled by Kelthane, ethion or wettable sulphur (0.2%).
Mite Blotch

**Symptoms**: Apparently a blotch on *Coelogyne* is due to an unidentified species of mite. The casts with appendages fore and aft may be found rather deeply sunken in the tissues of the leaf, which has been corroded and has turned black in characteristic patterns.

**Management**: Spray twice with Kelthane or Dimethoate at 2 to 3 week intervals before the plant flower. Ethion or wettable sulphur controls mite infestation in orchids.

Slugs

**Symptoms**: These mollusks feed on buds and blossoms, the surfaces of leaves, and the tender stems of orchids.

**Management**: For commercial orchid ranges, apply a 15 per cent metaldehyde dust 3 times at 10-day intervals to surfaces over which slugs crawl. Or spray with ½ spoon of metaldehyde; the manufacturer should be worn when making the applications. Zectran or Mesurol, used as directed by the manufacturer, also control slugs.

Nematodes — Fern Nematode (*Aphelenchoides ritzemabosi*)

**Symptoms**: The fern nematode, *Aphelenchoides olesistus*, which commonly infests ferns in greenhouses, also attacks orchid leaves. It forms brown or blackish spots bounded by the larger veins, like those on infested fern the base of the lower leaves and pseudobulbs of orchids, causing some deformation; the leaves may become brittle and snap off easily. Several species of nematodes have been found associated with the roots of orchids. The DeMan’s meadow nematode, *Pratylenchus pratensis*, has been reported as a parasite of orchid roots.

**Management**: Frequent application of furadan or aldicarb control the nematodes.

ANTHURIUM

**Diseases — Fungal**: Anthracnose (*Colletotrichum gloeosporoides* Penz.)

**Symptoms**: This is the most devastating disease of Anthuriums also known as Spadix rot or black nose, is mostly prevalent in moist greenhouses and high rainfall areas. It produces more or less circular spots, frequently along the veins of the leaves. They run together and form brown areas with a brownish yellow margin. The diseased tissues dry and fall off. The fungus also attacks the flowers in field as well as storage conditions and spoils them.

**Management**: To control the disease spray of fungicides like carbendazim (0.1%), captan (0.25%) or mancozeb (0.25%) was found effective.

Root rot

**Symptoms**: *Fusarium* sp., *Phytophthora* sp. and *Rhizoctonia* sp. cause root rot in anthuriums. Many fungi such as *Pythium* sp., spread through infected planting materials, splashing of rain or irrigation water. Root rot caused by *Pythium/Phytophthora* is prevalent in the tropics. Improper aeration leads to these diseases. The symptoms of root rot include stunted growth of plants,
reduction in the size of leaves and flowers, lack of leaf and flower lustre and a general reduction in vigour.

**Management** : Strict sanitation is to be maintained and drenching the soil with fungicides such as mancozeb (0.25%) and thiram (0.25%) is suggested. Excess application of fertilizers and pesticides is to be avoided. To control the spread of disease, captan (0.2%) given as soil drench is recommended. Chemicals like Aliette or Akomin are also reported to be effective.

**Bacterial** : Anthurium blight (*Xanthomonas campestris pv. dieffenbachiae*)

**Symptoms** : Appearance of small, scattered, angular water-soaked spots near the margins of leaves occur at the initial stage. The infected tissues are killed very soon and there will be a bright yellow halo around the spot. The main symptom is, however, characterised by the hollowing of plants. The bacterium is capable of becoming systemic. Disease incidence is encouraged by warm and wet weather. Affected parts of the leaf desiccate, causing distortion of leaf. On the spadix, blight causes rotting, often from tip onwards. The bacterium can spread through the planting materials taken from the diseased plants, irrigation water or splashing of rain and contaminated tools. Use of planting materials from diseased plants should be avoided. Application of ammoniacal form of nitrogen is to be avoided and the total quantity of nitrogen is to be reduced.

**Management** : Strict sanitation is to be maintained and the plants be sprayed thoroughly with streptomycin sulphate or oxytetracycline (200 mg/l) at weekly interval for six weeks.

**Insects and Other Pests — Scales**

**Symptoms** : Seven species of scale insects infest *Anthurium*: boisduval’s brown soft, distyospermum, fern, green shield, hemispherical and proteus. Plants infested by brown, yellow or white, flat or raised scales, especially on underside of leaves and also on stems, foliage sticky, sometimes sooty.

**Management** : Malathion or Sevin (0.2%) sprays will control the crawler stage of these scales.

**Mealybugs and Mites — Mealy bug**

**Symptoms** : Colonies develop on leaves, stems buds, flowers, fruits and other aerial parts of plants. Persistent infestation weakens the plants, especially when growing points are infested.

**Mites**

**Symptoms** : Mites develop on underside of leaves. As mite number increases the damage to leaves, buds and flowers increases. The worst red spider mite attack takes place in warm conditions.

**Management** : The former are controlled with Malathion (0.2%) sprays, the latter with Kelthane (8 ml/l).

**Red Spider Mite** (*Greenhouse red spider mite, red spider or the bean red spider mite, Tetranychus urtica*)

**Symptoms** : Spider mites are very small, oval-shaped, spider like, white green (sometimes brown red) transparent insects. They cause young leaves and buds to wither. They bore through the leaves and bud scales, causing them to roll up and leaves to curl up.
through the plant cells and suck up the contents, causing the cells to take on a silver-white
discolouration. The red spider occurs in the anthurium on the old leaf. With severe damage, this
takes on a yellow discolouration. The damage is visible on the flowers in the form of brown dots
on the spathe. At a far-advanced stage, a web can also be seen.

Aphids: This usually involves the green peach Aphid (*Myzus persicae*). Other species are
*Aphis gossypii, Aphis nicotiana, Macrosiphum euphorbiae* and *Aulacorthum solani*. Aphids
produce honey dew, on which the black fungus can grow. They cause spots on the flowers and
leaves. The aphids also withdraw plant saps and inject toxic substances that affect plant growth.
The aphid has many host plants, whereby re-infection will take place quickly. Therefore, remove
the weeds in and around the culture area. Aphids can also transmit viruses seen on the plant.
The attack of mites is more severe in summer months.

*Management*: Spraying the under surface of the leaves with Kelthane (0.2%) is recommended
to control these insects.

Snails

Symptoms: They chew the root tips, damaging the leaves and buds. If the leaves show large
number of small bubbles, this is usually caused by snails scaling off the tissue on the underside
of the leaf, leaving a brown layer of cork. The bubbles on the top of the leaf could be yellow.
When bubbles are discovered, check for the presence of snails. Snails and slugs appear during
rainy season and are difficult to control.

*Management*: They can be tempted with beet or potato slices. Metaldehyde based baits are
more effective.

Nematodes (Eelworms) *Meloidogyne, Radopholus similis, Pratylenchus infestans, Aphelenchoides fragarie*

Symptoms: Damage by *Meloidogyne* will result in poor growth, with swellings on the roots also
cause poor growth. However, the roots display brown spots (lesions) instead of swellings. In
the lesions are young eelworms, which will choke off the root in a short time. The first root
damage, caused by eelworms, can result in a secondary infection being caused by fungi, which
results in root rot.

*Management*: Nematodes can be controlled with aldicarb or furadan.

**GERBERA**

Diseases — Fungal

Foot rot and root rot (*Phytophthora de Bary, Pythium Pringsh, and Rhizoctonia solani* Kuhn)

Symptoms: These types of maladies are caused by soil borne pathogens either singly or in
combination. The plants are killed in nursery stage known as damping off and also at various
stages of crop growth. These pathogens are favoured by water-logged conditions and high
humidity.

*Management*: Seed treatment with Caplan (0.2%), use of healthy seeds so as to get healthy
nursery, avoidance of water logged conditions, good sanitation and proper application of
fertilizers are general control measures.
Anthracnose (*Colletotrichum gloeosporioides* Penz.)

**Symptoms:** It produces circular, scattered, reddish-brown spots, which coalesce with one another in moist weather and involve large areas thereby resulting in withering, rolling and drying of leaves.

**Management:** Spraying with Bavistin (0.1%) gives effective control. Excessive watering or overcrowding of plants should be avoided. Infected debris should be burnt in time.

Blossom Blight (*Botrytis cinerea*)

**Symptoms:** In cool moist weather of prolonged drizzling rains the disease is encouraged light brown irregular water soaked up area appear on flower stalks, which enlarge and coalesce producing distinct depressed lesions. Ultimately the infection spreads to the entire flowers. The stalk of the base is girdled which causes drooping and death of plants.

**Management:** Deep planting, bad drainage and and poor ventilation predispose the plants to infection and should be avoided. Infected plants should be removed and destroyed. Treatment with 0.1% benlate or 0.2% thiram helps in preventing the disease.

Powdery Mildew (*Erysiphe cichoracearum* DC and *Oidium erysiphoides f. sp. erysiphoides Link ex. Fr.*)

**Symptoms:** The affected parts are covered with white floury growth mycelial growth. The diseased areas get dried and fall.

**Management:** Spraying with Bavistin (0.1%), Sulfex (0.3%), Karathane (0.5%), effectively controls powdery mildews.

Bacterial — Bacterial Blight

**Symptoms:** The disease is characterised by small to large circular or irregular, brownish black leaf spots with or without concentric rings.

**Management:** Use of Spreptocycline (0.01%) was found effective.

Viral — Tobacco Rattle Virus

**Symptoms:** Characterised by yellow or black annulated leaf spots on the foliage.

**Management:** Soil sterilization to control the nematode vectors e.g. *Trichodorus* sp. and application of Aldicarb or furadan are recommended.

Insects — White Fly (*Trialeurodes vaporariorum*)

**Symptoms:** In greenhouse gerbera is subjected to heavy infestation of whitefly. Primary damage to the plant results from the effects of colonies feeding on young tissues which weakens the plant and distorts new growth. Secondary effects which are often more important result from fouling of leaves and stems with honeydew which encourages the growth of sooty molds.

**Management:** Application of 0.1% ultracidor 0.075 % actellic has been reported to manage the insect. In greenhouse trial, 8 applications (2/week) of actellic (primiphos-methyl) at 3ml/l has
been reported to give best result followed by lannate (methomyl) at 1g/l and tamaron (methamidophos) at 1ml/l. An integrated control by using plexiglass sticky traps have also been suggested to be helpful.

**Leaf Miner (Liromyza trifolii, L. soncho)**

**Symptoms:** Adults of these small winged insects lay eggs on the leaf. The larvae bore into the leaf and make irregularly shaped tunnels or blotches, which are generally, light yellowish tan to brown in colour. As these larvae mature they fold the leaf together with threads and feed on the inner surface.

**Management:** Dimethoate 0.1% gives good control. Combinations of yellow trap against the adults and aqueous spray of pyrazaphos against the larva within the leaf mines are very effective. Natural immigration of the eulophid *Diglyphus isaea* into the area have been reported to parasitize 90% of *L. trifolii* and effectively control the leaf miner.

**Mites (Hemitarsonemus latus and Steneotarsonemus pallidus).**

**Symptoms:** Leaves and flower buds are damaged and malformed flowers are produced.

**Management:** Sprays of Kelthane (1g/l), thiodan (2ml/l) or tedion (2g/l) were found effective.

**Aphids**

**Symptoms:** The insect infests young leaves and buds and cause injury by sucking the sap, which results in distortion of tissue.

**Management:** Sprays of dichlorvos 0.1%, oxamyl 0.05 %, 0.04% cypermethrin, 0.1% methomyl are reported to be effective.

**Nematodes — Southern Root-knot Nematode (Meloidogyne incognita).**

**Symptoms:** This nematode is occasionally serious on Gerbera. The growth of the plants are suppressed and the roots are damaged and hence flower production is effected.

**Management:** Use clean or formalin sterilized soil. Infested plants can be freed of the pests with hot water. Immerse bare-root plants in water heated to 40-42°C for 20 minutes. Faradan or aldicarb can also control nematodes.

**TUBEROSE (Plianthes tuberosa)**

**Diseases — Fungal**

**Foot and Tuber Rot (Sclerotium rolfsii)**

**Symptoms:** The disease appears in patches and cause wilt and stem rot. In moist humid conditions, a characteristic fan shaped mycelial strand of the fungus appear at the base of the infected plants, and in later stages brown mustard like round sclerotia develop on the mycelial growth. This fungus initially attacks roots and later spread to the tubers and petioles, which induce rotting.
Management: Soil application of Thiram (0.2%), Bavistin (0.5%), Brassicol (0.1%) or Zineb (0.3%) three times at 20 days interval has been recommended to control the disease. Soil drenching with commercial formalin (0.2%) and mercuric chloride (0.1%) was also found effective against this fungus.

Blossom Blight (*Fusarium equiseti*)

Symptoms: With the infection of this fungus light brown lesions develop on petals, which soon darken and results in the drying of the tissue. The blightened blossom drops off from the plants. Tips of the florets become brown under humid condition on which brown spores mass develops.

Management: Application of benomyl (0.2%) or thiophanate methyl (0.2%) as a foliar spray reduces the disease.

Bacterial — Flower Bud Rot (*Erwinia species*)

Symptoms: The young flower buds are affected initially by this fungus causing dry rotting of buds with brown scorched necrotic discoulouration of peduncles.

Management: The diseased plants are to be removed. Use of spreptocycline (0.01) was reported to be effective against the disease.

Alternaria leaf spot (*Alternaria polyanthi*)

Symptoms: It is characterized by faint concentric rings on midrib and rarely on the margin of leaves. It is prevalent in the rainy season. Flower peduncle is also affected showing circular to oval spots. The leaves and peduncles become necrotic and dry up with the infection.

Management: Spray of mancozeb (0.2 %) or iprodione (0.2%) at ten days interval helps in reducing the disease.

Insects — Aphids

Symptoms: The aphids feed on the flower buds and growing points.

Management: Spray of insecticides like malathion, or rogor (2ml/l ) helps in controlling the pest.

Thrips

Symptoms: Thrips damage the leaves, flowers, and flower stalks by sucking sap. It is sometimes associated with bunchy top symptoms in which malformed inflorescence in produced.

Management: Spray of endosulphan (2 ml/l) or malathion (1.5 ml/l) was reported to be effective against thrips.

Grosshoppers

Symptoms: The insects damage the young leaves and flower buds while feeding on them.

Management: To control the insects spray of plants with malathion (1.25 ml/l) or rogor (1 ml/l) at fifteen days interval can control the pests.
Red Spider Mites

**Symptoms**: Yellow striped spots and streaks appear on the foliage with the attack of this pest, which suck the sap. Ultimately the leaves become yellow, silver or bronze.

**Management**: To control the red spider mites spray of ethion (2 ml/l) or Kelthane (2 ml/l) is recommended.

**Nematodes**: The attack of nematodes is caused by *Meloidogyne incognita*, *Meloidogne javanica*, which causes yellowing and drying of leaves and retard growth. In severely affected plants the emergence of panicles is suppressed resulting in the loss of flower production. The bulbs also suffer by the nematode attack.

**Management**: To control the nematodes infestation application of furadan was found effective application of carbofuran (2 gm/plant) is recommended to control nematodes. Foliar nematode on tuberose was also reported, to be caused by *Aphelenchoides besseyi*.

**LILIUM**

Diseases — Fungal

**Foot rot (Phytophthora cactorum)**

**Symptoms**: Infected plants turn violet brown at the base of the stem and then the infection move upwards. The leaves become yellow acropetally. The severely infested plants fall over due to the collapse of the stem.

**Management**: Good drainage is very important for prevention of the disease. Cultivation in wet weather be avoided. The affected plants should be removed from the sight and destroyed. Hot water treatment of bulbs for 2 hours at 39°C followed by a 30 minute dip in 0.2 % benomyl eliminates infection and stimulates plant growth.

**Fusarium scale Rot (Fusarium oxysporum Schlechtend ex. fr.f. sp. Liliae)**.

**Symptoms**: The initial characteristic symptoms are foliage yellowing and wilting. Although the bulbs of these plants may appear healthy, the roots develop a reddish colored decay at their tips. The plants remain stunted with yellow foliage and with extensively rotted scales. In early infection, the scales develop brown to reddish necrotic areas which gradually enlarge, the infested scales later fall away or shatter from the basal plate.

**Management**: Some cultivars of *Lilium hansonii, L. sargentiae and L. maximoviczii* has been reported resistant. Disease resistant plants to *Fusarium* by using fusaric acid as a selective agent on pollens of various lily cultivars of known resistance to the pathogen were obtained. A high level of resistance is noticed in asiatic hybrids and to lesser extent in cultivars of *L. longiflorum* and moderate resistance is observed in oriental hybrids. Removal of infected plants the soil treatment with formalin, chlopicrin or steam sterilization have shown good disease control. Use of pathogen free stock in combination of fungicides, hot water and surface sterilization of scales used for bulblet production. Hot water treatment of bulbs for 2 hours at 39-40°C followed by a 30 minute dip in benomyl eliminates infection and stimulates the plant.
Addition of mycorrhizal fungi increases plant growth and offset the detrimental impact of root pathogen.

**Botrytis Blight** (*Botrytis elliptica* (Berk.) Cooke and *Botrytis cinerea* Pers. ex. Fr.)

**Symptoms**: Occasionally the growing points of the shoots are attacked and dieback occurs with no further growth. The first symptom of the disease initially appear as small, circular or elongated, sunken spots somewhat water soaked. The center of, which becomes reddish brown at first and gradually surrounded by a yellowish zone and becomes pale brown on enlargement. Flower buds thus produced are shriveled, distorted or disfigured depending on the severity.

**Management**: Use of disease free stock and resistant plant material such as *Lilium pyrenacium*, *L. regale*, *L. willmottiae* are recommended for healthy flower production. Removal of all old foliage and flower from field is necessary to eliminate the inoculum potential. For many years 2 per cent Bordeaux mixed with a spreader stick have served as a good control. Captan, zineb, thiram and other dithiocarbamate fungicides, which leave fewer deposits also, reduce the disease. Foliar sprays of carbendazim plus diethofenacol gave complete control of *B. elliptica* while cyproconazole, fenpropimorph and chlorothalonil fungicides have been reported to be effective. Fungicides such as captafol, chlorothalonil, febrom, mancozeb triforine, zineb and a mixture of thiophanate methyl and mancozeb (0.2%) effectively controls the disease. Smoky pellet formulations (Procymidone 30% + dichlofluanid dust) have been reported to be effective against this disease as compared to wettable powders in controlling the disease.

**Bacterial — Soft Rot** (*Bacillus lili*, *Pectobacterium carotovorum*)

**Symptoms**: The characteristic symptoms are soft and wet decay of bulbs.

**Management**: All diseased bulbs should be discarded. Healthy bulbs should be planted in a well-drained soil. Care should be taken for avoiding injury to the bulbs while lifting from soil.

**Viral**: *Lilium*, particularly are extremely susceptible to infection by viruses, especially those transmitted by aphids. Gardeners often find lily stocks have a much shorter working life than for irises and narcissi before they succumb to the build up of viruses. The reason may be due to the fact that the aphids colonise *lilies* and thus introduce viruses like *Lily symptomless Virus*, *Cucumber Mosaic Virus*, *Lily virus*, *Tulip Breaking Virus* etc.

**Tulip Breaking Virus**

**Symptoms**: This virus produces severe leaf mottling, distortion of the flowers sometimes giving rise to notched petals and a general reduction in growth. Transmitted by the aphids *Myzus persicae*, *Macrosiphum euphorbiae*, and *Aphis fabae*, diseased darwin tulips commonly are the source of infection.

**Lily Symptomless Virus**.

**Symptoms**: A general stunting is being reported.

**Cucumber Mosaic Virus**

**Symptoms**: Produces little effect other than growth reduction, but when both this and *Lily* symptomless virus occur together, characteristic elongate flecks develop on the leaves at first.
yellowish but later grey or necrotic. The flowers may appear abnormal but this symptom is not invariable. The aphid *Aphis gossypi* transmits Lily symptomless virus.

**Management**: Tissue cultured propagation has freed numerous taxa of these pathogens. Stunted and mottled plants should be collected and destroyed and bulbs from the diseased plants should not be used for propagation.

**Insects — Aphids**

**Symptoms**: Five species of aphids infest this host: crescent-marked lily, green peach, foxglove, melon, and, purple-spotted lily.

**Management**: Spray with Malathion or Sevin (0.2%) whenever aphids appear.

**Fuller Rose Beetle** (*Pantomorus cervinus*)

**Symptoms**: This grayish-brown weevil, with a short, broad snout and a white diagonal stripe across each wing-cover, attacks lilies and a wide variety of other plants. It is a night feeder, eating ragging areas from the margins of the leaves.

**Management**: Spray susceptible plants with Sevin (0.2%).

**Stalk Borer** (*Papaipema nebris*)

**Symptoms**: The common stalk borer that attacks asters, hollyhock, phlox, and other garden plants may be found feeding on stalks of lily. The larvae are about 1 inch long.

**Management**: To save valuable plants it may be worth while to slit the stalks open and destroy the larvae feeding in the pith. Nearly burdock, ragweed, and other plants on which eggs are laid should be destroyed. Spraying with methoxychlor (0.1%) may be helpful.

**Thrips** (*Taeniothrips simplex* and *Liothrips vaneeckeii*)

**Symptoms**: While thrips are not generally troublesome in lily culture, they may congregate occasionally in considerable numbers between the bulb scales of certain species. The infested scales turn light brown and dry out, and bulb decay may follow through secondary infections of fungi. Plants grown from infested bulbs are stunted.

**Management**: Soaking the bulbs in Tedion as suggested for bulb mite, below, should control this pest.

**Bulb Mite** (*Rhizoglyphys echinopus*)

**Symptoms**: Marked injury to lily bulb results from infestation by mites, which is made easy by the loose structure of the bulbs. The mites feed around the basal plate of the bulb and destroy the roots. Later they infest the scales, and burrow into the stems. Leaves and stems developed from infested bulbs suddenly become yellow and the basal parts of the stem are corroded. Death of infested plants is not infrequent. Various bacterial and fungus rots enter the bulbs through wounds made by the mites.

**Management**: Bulbs for planting should be carefully selected and infested bulbs discarded.
Bulbs should be grown in properly drained soil and crop rotation should be practiced. They should be stored at 1.6°C, since this prevents feeding by the mites during storage. Soaking mite-infested bulbs for 24 hours in a solution containing 1 g of 25 per cent wettable Tedion in water will also provide control.

**Bulb and Leaf Nematode (Aphelenchoides fragariae).**

**Symptoms:** This nema causes dieback of field grown Easter lilies. The normal green color in the leaves becomes blotched with yellow, fading into a brownish-yellow, and finally to a dark brown. The nemas live over in the bulbs to initiate new infections. Nema-infested bulbs forced new infections. Nema-infested bulbs forced in the greenhouse may produce “blind” buds, which fail to produce flowers.

**Management:** Commercial stocks of bulbs should be soaked for 1 hour in a hot water formalin bath. One part of commercial formaldehyde solution (38 to 40 per cent) in 200 parts of water heated to 38-40°C is the standard treatment.

**Nematodes — Root Lesion Nemas (Pratylenchus pratensis and P. penetrans)**

**Symptoms:** These nemas cause premature yellowing of Easter Lily foliage. Infested plants may be severely stunted and numerous dead spots or lesions are present on the roots.

**Management:** Pruning away all roots from infested bulbs and rotation of plantings are suggested. Heavily infested soils should be treated with an effective fumigant before lilies are replanted in them. The chemicals Mobilawn (formerly known as VC-13) and Nemagon have proved very effective in some areas.

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**TULIP**

**Diseases — Fungal**

**Fire Disease (Botrytis tulipae (lib.) Lind.)**

**Symptoms:** The leaves prior to emergence get infected. They became stunted, malformed, distorted and fail to unroll. Under moist weather masses of fungal spores (conidia) and sclerotia are formed on the outer surface of the infected tissues. Leaf spotting is of non-aggressive and aggressive type. Small necrotic areas are generally marked by dark green, water soaked areas in non-aggressive lesion which do not increase in size and no conidia are produced on them. Aggressive lesions have whitish gray or brown with water soaked margins that can enlarge and able to produce more spores that may result in an epidemic form leading to significant reduction in bulb yield. Increase in lesion size depends entirely upon the production of spores and the duration of moisture during infection. Flowers may also be attacked. Fruit capsules are most susceptible, part and sclerotial bodies cover seeds. In the underground infection, bulbs are attacked first. Infection travels from mother to daughter bulb sclerotia are formed in the outer husk of the affected bulbs. With this, the outermost fleshy scales develop small round to oval, sunken spots, the center of which contains a yellow gray border. The stems produced by these bulbs are shorter and in few cultivars a slight streak is apparent on flowers.
Management: Discard the infected bulbs. Removal of infected shoots, just below ground level upon emergence and flower before anthesis is helpful in limiting the disease spread. Bulb dip prior to planting in benomyl, thiabendazole or 2 percent Formalin for 30 minutes reduces the carry over of inoculum and subsequent production of fireheads. Iprodione and Vinclozolin provide significantly higher level of disease control in flowering period of the crop. Spraying with benomyl (0.1%) and maneb (0.25%) just after leaf development is recommended.

Fusarium Bulb rot or Basal Rot (Fusarium oxysporum Schlenhtend ex Fr f. sp tulipae Apt)

Symptoms: The first visible signs of infection on the bulbs are small, pale brown or gray sunken flecks on the outermost fleshy scales that become dark brown with age and enlarge in size. Rotting usually starts at or near the base of the bulb and results in exudations. Fungus produces white or pink mycelium and spores on bulb formed in warm, damp sites. The infected tissues shrink, become firm and appear ring shaped. Leaves in general do not wilt but remain upright and often develop a characteristic purple color. Foliage produced on infected bulb senesces early. Flowers produced may be blasted or deformed.

Management: Delayed planting and early lifting avoid soil temperature that favors disease development and therefore, provide natural resistance in bulbs. Diseased stock should be stored separately from the healthy stock in well-ventilated facilities that reduce production of ethylene. The storage temperature should be maintained below 15°C. Rotation for minimum of 3 years should be practiced. Dipping of bulbs immediately after lifting (Within 48 hours) in benzimidazole fungicides has provided excellent control. A satisfactory control is achieved by dipping bulbs for 2 hours in a 0.5 % Formalin solution. Planting when soil temperature is below 10°C reduces the infection. Benomyl and thiophanate (0.05%) provided very good control of the disease.

Pythium Root rot (Pythium ultimum (Trow) var. ultimum)

Symptoms: The attack in fields is visible by gaps and irregular growth of shoots, which may fail to emerge. Severe stunting of plants is apparent. Flowers and bulbs may wither before maturity and may remain small and loose their quality. The affected roots appear translucent with watery spots. The vascular tissues turn brown, roots reduced to a fragile hollow cylinder containing the remnants of the conducting tissues and eventually get destroyed. Primary symptoms on base of bulbs are soft gray spots often with brown borders that release a distinct odor.

Management: Soil sterilization with steam or Formalin before planting gives good results. Bulbs should be planted in well-drained and sterilized soils. Beneficial effects of fluorescent Pseudomonas isolate E113 and Trichoderma harzianum against root rot fungi was achieved either by mixing the bacteria through the soil or by dipping the bulbs in a bacterial suspensions immediately before planting.

Physiological Diseases

Sunscald: Dryland and shriveling of flower parts especially along the upper edges has been found to be caused by sunlight under dry conditions.

Management: Shading the flowering plants in the greenhouse is effective.
Frost Injury: Among unfavorable conditions frost has been reported as a cause of a disease. Oblong or oval spots develop along the veins. This injury is not common.

Flower Stalk and Stem Collapse, "Topple": Certain varieties of tulips develop weak watersoaked spots, with an exudation of liquid either on the upper half of the flower stalk or on the lower parts, or even on the neck near the bulb. Flower stalks soon shrivel and collapse. Some stems may topple without first showing water-soaked spots. The plants otherwise appear to be in excellent condition. The disease is said to be caused by insufficient ripening of the bulb after wet, cool summer weather and by forcing of tulips in clay soil or at excessive temperatures.

Management: Avoid high temperatures and high humidity in forcing. See that bulbs used for forcing ripen thoroughly. Spreading out the bulbs in the forcing house for 2 to 3 weeks is recommended as a secondary ripening period. Do not force the bulbs too early especially after wet, cold years. The varieties susceptible to this disease should be put in pots early to establish a strong root system. They may then be forced later. Some varieties are less susceptible and are to be preferred if this disease gives trouble.

Retarded Growth: If bulbs are stored or heated-in under excessively warm conditions or are insufficiently ripened, the shoots are greatly retarded or are suppressed entirely.

Winter Injury: When bulbs are planted late in the fall in heavy clay soil or where drainage is not adequate, roots fail to grow and shoots are distorted and abnormal. Bulb decay follows.

Leaf-Flower-Fusion: Sometimes an abnormal fusion of the leaves and flower petals. The cause of this condition has not been determined, but the use of hormone-type weed killers during the previous growing season are possible causes.

Insects and Other Animal Pests

Tulip Bulb Aphid (Dysaphis tulipae).

Symptoms: This aphid also attacks iris, freesia, gladiolus, and crocus. It is gray with a waxy appearance and clusters under bulb coats. It may also infest aboveground parts.

Management: If aphids are present before planting dip bulbs in Diazinon. Aphids that later appear on the foliage can be controlled with malathion sprays.

Crescent-Marked Lily Aphid (Neomyzus circumflexus)

Symptoms: This aphid is yellowish-green with black markings on the body. It occasionally attacks tulips grown in greenhouses. The green peach aphid, Myzus persicae, is not itself very troublesome to tulips, but it is a vector (carrier) of virus disease. The tulip leaf aphid Rhopalosiphoninus tulipae infests tulips and iris leaves and may develop on the bulbs in storage, as does the tulip bulb aphid.

Management: Same as the bulb aphid.

Narcissus Bulb Fly (Merodan equestris).

Symptoms: Tulip bulbs are only occasionally destroyed by the larvae of these flies. If affected bulbs are lifted and opened, single, large, dirty grey brown, fleshy larvae up to 20 mm long, may
be found inside rotting tissues. Larvae of small narcissus flies may be seen inside the rotting tissues. The large narcissus fly mainly attacks bulbs growing in sunny open conditions and severe attack may kill bulbs completely so that no foliage and flowers are produced in spring.

Management: as in Iris.

Bulb Mite (Rhizoglyphus echinopus).

Symptoms: These mites are colored yellowish-white with a pink tinge, are bead-like, shining, and slow-moving. They are large enough to be readily seen even without a hand lens. Bulbs that are infested by these mites before they are dug deteriorate rapidly. The mites are most active at 20-25° C, and at high humidity. If infested bulbs are stored at a low temperature, so that the mites remain inactive and thus escape detection, they will be planted for uninfested bulbs; the mites then continue their work, causing the leaves to turn yellow and blasting the flowers. They move from one bulb to another in a planting, attaching themselves to some other insect or soil organism. The outer crust of the bulb scales becomes hardened and light chocolate-brown. The pulp of the scale is dry and broken up into fine more or less corky fragments. Hundreds of mites can be found working in this pulpy mass. The damage done by mites opens the way for rots caused by fungi and bacteria and to infestation by other organisms.

Management: Discard all bulbs in which heavy infestation is evident. Mites on affected bulbs can be killed by fumigation.

Nematodes — Stem and Bulb Nematode (Ditylenchus dipsaci)

Many leaves are deformed, bent and yellowish; they later turn brown. The formation of blossoms is much reduced. Individual scale of the bulbs turns brown and become rotted. Cross-sections of the bulbs show a dark ring. The infected part of the bulb scales or leaves often become swollen or distorted. The nematodes migrate from infested leaves into the bulbs and then by the decay of the bulbs and spread in the soil where they spend the winter. They also migrate through the soil to sound bulbs. This nematode affects a number of other garden plants, such as phlox, amaryllis, and tulip.

Management: Soil must be properly sanitized and treated with nematicides like nemaphos 0.1% (2 kg/ha). Bulb treatment with hot water at 43-44 °C or immerse in nemaphos @ 3g/l for two hours.

DAHLIA

Diseases — Fungal

Powdery Mildew (Erysiphe cichoracearum DC): The leaves and young stem at first develop circular spots, which gradually increase in size, and ultimately the entire foliage is covered with a white powdery growth. Generally warm humid conditions favor the growth of this disease.

Management: To check the disease the plants should be dusted fortnightly with sulphur dust, or sprayed with wettable sulphur, dinocap, benomyl and carbendazim.
Stem rot (*Sclerotinia sclerotiorum* (lib.) de bary and *Sclerotium rolfsii* Sacc)

**Symptoms:** The disease is soil borne in nature. The stem rot fungus attacks the main stem and branches near the base of the plant a white mold may completely encircle the stem. Plants growing in heavy wet soil infected with this fungus ultimately wilt and die.

**Management:** To avoid the occurrence of this disease it is advisable to change the growing area. A wide spacing and good drainage will help to keep the disease in check. Affected plants should be uprooted and burnt. For *S. rolfsii* control, the tubers are treated in benomyl (0.1%) for 30 minutes after harvest and before planting. Drenching of soil with quintozene (0.2%) is recommended to reduce the infection.

Wilt (*Verticillium alboatrum* and *Fusarium sp.*)

**Symptoms:** The plants wilt and die because of the blockage or destruction of water-conducting vessels, or death of the living tissue due to toxins produced by the fungus. Wilted plants should be destroyed and only healthy tubers should be used. The only characteristic symptom is a brown or black discoloration seen in the conducting elements of the stem. This discoloration can be traced both upwards in the plant and downwards towards the roots but if it is confined to the basal parts it is more likely to be caused by root damage than by a wilt.

**Management:** Wilt diseases are very difficult to tackle in gardens. When plants are lightly infected, pack the bases of the stems with damp peat, which may promote healthy new root growth. After removal of diseased plants, thoroughly disinfect greenhouse or garden soil, all pots, benches, tools and raise the crop in sterilized composts.

Smut (*Entyloma calandulae f. sp. dahliae*)

**Symptoms:** Circular or elliptical pale yellow-brown spots arise on the leaves, normally at seedling stage which later enlarge, darken and merge but usually retain a yellow margin. Darker areas within the lesions can sometimes be seen in a strong light. It appears first on the lower leaves, then spreads upwards and large areas of leaf tissue may ultimately die.

**Management:** Burn diseased foliage and remove any leaves adhering to the tubers before storing. Do not grow dahlias in contaminated soil for at least five years. Three or four fortnightly sprays of captan (0.2 %) may check the disease on growing plants, if applied early in the season.

Bacterial — Crown Gall (*Agrobacterium tumificiens*)

**Symptoms:** Usually irregular but sometimes more or less spherical, knotty swellings can arise on almost any part of affected plants but occur most typically at the junction of root and stem. Infected plants become stunted and the shoots spindly.

**Management:** Dipping roots at time of planting in streptomycin sulphate solution can prevent the disease. Roots and crowns of plant with tumors should be destroyed and changing the location of planting will also help to manage the disease.

Bacterial Wilt (*Pseudomonas solanacearum*)

**Symptoms:** Infected plants usually droop and wilt rather suddenly. The conducting system will be found plugged with yellowish masses of bacteria, which ooze out when the stems are cut. The
wet soft rot of the stems near the soil is characteristic and distinguishes this wilt from that caused by the *Verticillium* and the *Fusarium* wilt fungi.

**Management**: Destroy all wilted plants; be sure that no infected parts are thrown into the compost pile. This bacterium, like the wilt fungi, winters in the soil. Heavily infested soil must be pasteurized with steam. The best way to avoid this disease is to practice rotation, as the farmer does to avoid soil-borne diseases.

**Bacteriosis** (*Erwinia carotovora* var. *carotovora*): This disease appears as a browning and softening of the stem. The layers of pith that line the hollow stem are moist and blackish with the rot, which extends into the bark. If one uses a compound microscope, great masses of the large bacteria can be seen swimming about. The rot gives off a foul odor. This disease also affects the tubers.

**Control**: Special methods for the control of this disease have not as yet been found. Destroy the affected parts of the plant so as to prevent the spread.

**Viral — Mosaic**: Mosaic caused by *Marmor dahliae* is one of the serious diseases reported for dahlias. The leaves become mottled and develop pale green bands along the midribs and larger secondary veins. Yellowish or pale green vein banding is the most common symptom. It is also accompanied with twisting or crumpling of leaves. It is transmitted by aphids most notably *Myzus persicae*.

**Management**: Growing of cuttings in closed environment. Careful selection and multiplication from symptomless plants is essential.

**Spotted Wilt**

**Symptoms**: The common symptoms are mottling of leaves, stunting and ringspot symptoms. Disease spreads by thrips.

**Management**: Spraying of 0.1% malathion or metacid to control insect vectors is recommended. Using virus free tubers or cuttings can also check the disease.

**Insects — Aphids**

**Symptoms**: Three species of aphids infest dahlias; bean, green peach, and leaf-curl plum. There are also several species of root aphids, which may attack dahlias below the surface of the ground. They are carried about by ants.

**Management**: Spray with Meta-Systox R or Malathion (0.2%) as soon as the aphids appear. Frequent tilling of the ground kills off the aphids. Wetting the soil around the base of each plant with a dilute solution of Diazinon or Malathion is also helpful.

**European corn Borer** (*Ostrinia nubilalis*).

**Symptoms**: The borers are at first flesh-colored, later smoky and reddish along the back. Each abdominal segment is marked with four dark spots, which carry stout spines. Beginning in August or about the first of September each moth lays about 15 or 20 eggs on the flowering tips. After hatching (in about a week) the young larvae feed on the tender bud ends, flower parts, and
leaves causing them to become destored and turn brown. The affected tips usually die completely, after which the borers move down through the stem, causing a wilting of all parts above the lowest region of invasion. This borer infests a large number of crop plants as well as many species of ornamental plants.

**Management:** For good control dahlias should be sprayed every week during the summer months with a mixture of Sevin (0.2 %) and Kelthane (8 ml/10 l). Sanitation is very important. Stalks of corm, dahlia and weeds susceptible to this borer should be cleaned up and destroyed in late fall, or certainly before mid-April, to destroy overwintering borers.

**Stalk Borer** (*Papaipema nebris*) and **Burdock Borer** (*P. cataphracta*).

**Symptoms:** Since these insects are not very numerous, individual borers may be killed by inserting a wire in each puncture. The destruction of weeds and other kinds of plants liable to infestation in the vicinity of the dahlia planting is helpful against these pests as against many others.

**Management:** In areas where the pests are especially troublesome, spray with a methoxychlor-Kelthane mixture in late June and repeat twice at 10-day intervals.

**Leafhopper** (*Empoascus fabae*)

**Symptoms:** These insects cause a discoloration of the leaf, which appears first along one margin and spreads toward the mid-vein. The affected area is at first pale yellowish; later it becomes brown and brittle. The infested plants often become quite stunted unless the leafhoppers are controlled. The insects are small, slender, pale green, about 1/8 inch long. They feed on many species of plants in the vegetable garden as well as in the flower garden. The rose leafhopper, *Edwardsiana rosa*, also attacks dahlias.

**Management:** Spray with malathion or Meta-Systox (0.2%) when the plants are 8 to 10 inches tall and repeat every 10 days until flowers appear.

**Bugs** (*Lygus lineolaris* and *Poecilocapsus lineatus*)

**Symptoms:** The tarnished plant bug and the four-lined plant bug attack dahlias as well as many other plants.

**Management:** Same as for leafhoppers.

**Thrips** (*Heliothrips haemorrhoidalis, Frankliniella tritici, and Thrips tabaci*)

**Symptoms:** Three species of thrips are apt to infest the flowers; they rasp the surface and feed on the exuding juice. The under surfaces of petals turn whitish and wither.

**Management:** Same as for leafhoppers.

**Mulberry Whitefly** (*Tetraleurodes mori*)

**Symptoms:** The larval stage of this whitefly is elliptical, 1/35 inch long, jet-black edged with a white fringe of waxy filaments. It adheres closely to the lower surfaces of the leaves. The adult is a small, very active whitefly.
Management: Spray the lower leaf surfaces with malathion to control the nymphal stage, or with Resmethrin to control the adults and nymphs.

Two-Spotted Mite (Tetranychus urticae)

Symptoms: This mite feeds on the undersides of leaves, where it sucks the juice from the cells; the leaves turn pale and become spotted on the upper sides. The eggs and the mites themselves are usually covered with a delicate web.

Management: Spray with miticide.

Cyclamen Mite (Steneotarsonemus pallidus): This mite has been found on green-house-grown dahlias

Nematodes — Root Knot Nematode (Meloidogyne incognita and M. hapla): Two root knot nemas occur on the roots of dahlias when plants are grown in infested soil.

Potato Rot Nema (Ditylenchus destructor)

Symptoms: Diagnosis for this pest is difficult because of the lack of aboveground symptoms of any striking root symptoms. All tuberous roots having a cortex with unusual transverse and longitudinal cracking, sloughing, or flaking of the surface, or rotted areas, should be examined for the presence of this pest.

Management: Hot water treatment of tubers may be effective.

AMARYLLIS

Diseases — Fungal

Red Spot (Stagonospora curtisii (Berk.) Sacc)

Symptoms: The tips of young shoots develop a red-brown, typically scorched appearance soon after they emerge. Flower stalks are severely stunted and distorted. It causes bright red or vermilion spots, which become soft, brown and sunken as they enlarge. In humid conditions fungal mycelium may develop. The centre of the lesions, which always retain red color at the edges. Leaf scorching is also frequent in some areas.

Management: Use of benomyl (0.2%) is recommended against this disease. Infected bulbs should be discarded. Diseased leaves should be removed and burnt. Plants should be sprayed with Zineb (0.2%) or Bordeaux mixture with a sticker as soon as the disease appears and the spray may be repeated at fortnightly intervals until blooming.

Viral — Mosaic

Symptoms & Management: The leaves show light green to yellow mottling. The plant vigour and flower quality is adversely affected. Rouging out and destroying all affected plants and using disease free planting material is recommended.
HIPPEASTRUM

Diseases — Fungal

Soft Rot of Bulbs [Botrytis cinerea Pers., Rhizopus stolonifer (Fr.) Linder and Sclerotium rolfsii Sacc.]

**Symptoms:** The disease is serious in stored bulbs under humid weather. One or few large, irregular, red-brown and sunken lesions develop on the sides of the bulbs and small pinkish bodies may be present beneath the skin of the central part of the lesions. On bulbs, a soft rot spreads below the lesions or more seriously, from the base into the bulb tissues and a blue-green mould may also develop.

**Management:** Same as discussed for other bulbous crops. Bulbs may be handled carefully which predisposes them to infection. Such careful handling is particularly important when they are lifted prior to storage while another common cause of damage at this time is allowing them exposure to direct sun. Dipping bulbs for 15-30 minutes in a suspension of benomyl or thiofanate-methyl before planting protects from bulb rots. Any growing plants showing symptoms should be carefully dug up, together with a spadeful of surrounding soil, and destroyed. Combination of hot water treatment and dipping in benlate (0.5%)

Grey Mold (Botrytis cinerea)

**Symptoms:** Very common and widespread on the flowers and bulbs of many host plants, sometimes associated with stem and leaf rots or other damage by the same fungus. There may be rotting of buds, flowers or flower stalks or petal spotting (usually off white or brownish). The fungus spreads rapidly by means of airborne conidia produced on the mould and persists in the soil as sclerotia or saprophytically on plant debris.

**Management:** Grey mold control is basically synonymous with good hygiene, good ventilation, avoidance of overcrowded, damp and shaded situations outdoors; removal of buds or flowers that have any reason become moribund as they may easily be colonised by the grey mould which can then spread to affect more healthy organs; carefully remove affected flowers and buds and spray plants with dichlofluanid (0.1%), benomyl (0.2%) or thiofanate-methyl (0.2%) to be repeated if the disease reappears.

Root rot and Foot rot (Phytophthora, Pythium debaryanum)

**Symptoms:** Although the primary effects of the disease are seen on the roots or stem bases the earliest signs of damage are often indicated by the leaves, which may be smaller than usual, turn yellow and wilt, suddenly. Flowering may be reduced and when the plants are pulled the root systems are seen to be feeble, blackened and or decayed.

**Fusarium rot**

**Symptom:** This pathogen attacks the root system and basal plate of the bulb. Overwatering promotes the spreading of disease.

**Management:** Soil sterilization is beneficial.
Fire Red Spot (*Stagonospora curtisii*)

**Symptoms**: This disease is characterized by red blot on the bulb scales, floral stalk or floral bud.

**Management**: Dipping of bulbs in Mancozeb if observed on the bulb as pre-plant treatment or spray of the chemical.

Viral — Cucumber Mosaic Virus

**Symptoms**: Over the leaf surface large yellowish green patches appear. Hence it causes yellow stripes and spots on leaf surface.

**Management**: The vector should be controlled by malathion (0.2%) spray at fortnightly interval. Sterilized knives should be used while propagating the bulbs.

Tomato Spotted Wilt

**Symptoms**: Numerous yellow spots appear on the leaves and the plants die ultimately.

**Management**: Since the disease is spread by the Thrips, spray of malathion (0.2%) or rogor (0.2%) is suggested to control the thrips.

Hippeastrum Mosaic Virus

**Symptoms**: It is characterized by light and dark green stripes on leaf margins.

**Management**: The disease is transmitted by aphids and their control is suggested. To prevent spreading of diseases sterilized knives should be used while propagating the bulbs.

Insects (Common to Amaryllis and Hippeastrum)

Mites (*Rhizoglyphus echinopsis, Tetranchus bimaculatus, Tarsonemas laticeps*)

**Symptoms**: Leaves usually become discolored, often showing characteristic bronzing and in severe attacks the leaves may wither and die. Secondary damage may be caused to the bulbs.

**Management**: Hot water treatment as described in other bulbous crops is useful in controlling the disease.

Thrips (*Taenothrips simplex*)

**Symptoms**: These insects suck the juice from leaves, flower stalks and flowers.

**Management**: Application of dust containing chlordane or dieldrin at weekly intervals is suggested. The pest can also be controlled by the spray of rogor (1 ml/l) or malathion (2 ml/l) at weekly interval.

Aphids

**Symptoms**: Aphids suck the sap of the surface.

**Management**: Spray of Malathion (0.2%) at fortnightly interval was reported to be effective.
Caterpillar (*Polytela gloriosae*)

**Symptoms**: These insects eat leaves particularly during rainy season.

**Management**: Application of parathion (0.02%) or endosulfan (2 ml/l) effective to control the pest.

Nematodes — Root Rot Nematodes (*Pratylenchus scribneri*)

**Symptoms**: Stunted growth of the plant

**Management**: Soil sterilization through methyl bromide - sodium or chloropicrin was reported to be effective. Hot water treatment (43.3-43.9 °C) of plants for two hours is also suggested. Soil application of aldicarb, carbofuran and fenamiphos (7.5 kg/ha) before planting the bulbs, have been reported to be effective.

**ALSTROMERIA**

Diseases — Fungal

**Damping Off** (*Pythium spp.*)

**Symptoms**: This disease affects juvenile or succulent tissues. The roots of the plants turn waxy and rot. This is the most common and troublesome garden disease type, affecting the seedlings of a very wide host range. Young seedlings may die out in more or less circular patches, the larger affected plants sometimes having stem lesions at or about soil level.

**Management**: Sterilization of soil media is suggested. It is advisable to spray benomyl or thiophanate methyl @ 0.2% to all bedding plants.

**Stem rot** (*Rhizoctonia spp.*)

**Symptoms**: The stems start rotting at the soil level.

**Management**: Drenching the planted area with PCNB.

**Grey mold** (*Botrytis cinerea*)

**Symptoms**: The disease is prevalent when the plants become crowded and air flow is restricted. Brown spots appear on leaves and flowers.

**Management**: Spray of benomyl or chlorothalonil (0.1%) is effective in controlling the disease. Restricted watering and improved ventilation will help.

Viral — Tomato Spotted Wilt Virus

**Symptoms**: The most familiar symptom is leaf mottling of very variable colours, ranging from an indefinite pale-green patchiness to a vivid mosaic of bright yellow or green.

**Management**: Use of virus free-planted material is suggested.
Insect Pests — Aphids

**Symptoms**: They are one of the most important groups of pests attacking garden plants. They feed on young tissues and make the plant weak. Secondary effects result in fouling of stems and leaves with honeydew, which encourages the growth of sooty molds.

**Management**: The spray of metasystox (2 ml/l) can control this insect.

Whiteflies

**Symptoms**: Adults, eggs and scales present on the underside of leaves and upper surfaces are often fouled with sticky honeydew and sooty molds. In severe cases plant vigour is reduced and leaves develop yellow spots and other discoloration.

**Management**: Prevent serious damage by examining plants regularly. If adult or immature whiteflies are visible spray thoroughly with malathion, rogor or dimethoate.

Red Spider Mites

**Symptoms**: Infestations first show as a very light speckling or as localised pale yellow spots on the upper surface of leaves. Careful examination of the underside of leaves with a hand lens reveal colonies of mites. As the infestation becomes severe the leaves get discoloured often showing characteristic bronzing.

**Management**: The spider mites can be effectively controlled by the spray of dimecron (1 ml/l) or Kelthane (2 ml/l)

Thrips: Thrips are difficult to control. Thrips carry tomato spotted Wilt Virus, which is devastating in this crop.

IRIS

Diseases — Fungal

**Bulb Rot or Blue Mould (Penicillium corymbiferum Westl)**.

**Symptoms**: The disease is chiefly manifested in storage. It spreads either from the base or from relatively large lesions at the site of the bulb. Symptoms are quite variable on bulbs the fleshy scales beneath the tunic develop white to greenish gray rot, covering the whole bulb. The tunic itself turns hard and chalky. Plants emerging from infected bulbs may get stunted with limited root growth, turn chlorotic, lacks flower and die prematurely. The fungus gets associated with the musk rot at the leaf and stem bases. Pathogen often enters through wounds created by root initiation process or by any other agency in heavily contaminated soils high relative humidity and 17°C temperature results in heavy infection within 3 days in wounded bulbs. Ethylene or ethephone treatment used for early forcing performance in iris cultivars does not predispose iris bulbs to rots. Prolong cool, moist conditions early and very late digging, predispose bulbs for rapid infection. Environmental factors like warm temperature and high humidity on the other hand decreases the disease severity.
Management: The disease can be controlled by preventing mechanical damage to the bulbs, manipulation of storage temperature and humidity requirements and adequate ventilation during storage is essential to keep bulb healthy. A very early or late digging and planting of diseased bulbs should be avoided because early lifting leads to more than 30 per cent loss of yield. Sometimes fungicidal dips with thiram and benomyl prior to planting are suggested. Sterilization of the bulbs in one per cent Formalin before forcing induces, reduced fungal infection (6%) as compared to 13 per cent infection in untreated lots.

Crown Rot (Sclerotium rolfsii Sacc. And S. delphinii Weleb)

Symptoms: The pathogen attacks the base of the leaves and flower stalks and induces rot that cause the leaves to die back. Crown portion is coated with a white fan like growth of the fungal mycelium containing numerous sclerotial bodies. Warm and moist storage conditions are favorable for spread of the pathogen in storage. The disease is common on Rhizomatous iris

Management: Since the disease is soil borne hence, the control of the disease is difficult and expensive. The infected stocks should be discarded. Removal of infected plants and contaminated soil surrounding the diseased bulb upto a distance of a foot helps in managing the disease spread. Early digging of bulbs and sun drying immediately before storage is effective. In addition deep ploughing, three to four years' rotation is helpful in lowering down the inoculum. Chloropicrin as soil fumigant and terrachlor (PCNB) or quintozene as dust applicant have been recommended. Application of Trichoderma harzienm either as a bulb coating or broadcast treating soil with quintozene or soil solarization prior to planting are reported to be effective in reducing the incidence upto 93 % and increasing the yield by 35 to 41 %.

Ink disease (Drechslera iridis (Oud) Iris)

Symptoms: The initial symptoms begin as minute spots and streaks and enlarge to dark reddish brown lesions with brown to black masses of spores. Infected leaves, stems and flowers collapse and appear blighted. Infected debris and bulbs to a limited extent act as a source of primary infection.

Management: To eliminate infection, burning of straw, removing diseased bulbs and older leaves, weeding operation, deep ploughing, 3-4 year rotation, raking up and hot water plus Formalin treatment of bulbs are essential to achieve a good control of the disease. Regular spraying during leaf spotting phase with a dithiocarbamate fungicides is helpful in reducing the severity of crop infection.

Leaf Spot (Mycospharella macrospora (Bleb.) Jousted)

Symptoms: Infection is visible only on leaves of rhizomatous irises but in bulbous iris leaves, stem and flowers are infected. Early diagnosis can be made by looking the first symptom that appears on both surfaces of leaf as minute brown spots surrounded by a dark green water soaked halo, which later turn yellow. Lesions enlarge and assume an oval shape bordered by a red brown zone and grayish centre.

Management: To prevent infection removal and destruction of the older leaves prior to spring has been recommended. Spraying with mancozeb, Bordeaux mixture and zineb is quite effective.
Late planting, three to four years' crop rotation and cultural methods to promote good airflow are admissible for commercial production of bulbous irises.

**Bacterial — Soft Rot** *(Erwinia carotovora subsp. carotovora (Jones) Bergey et al.)*

**Symptoms:** The soaked lesions on the leaf blades developing into large irregular spots appear. With the progress of the disease sheathes and rhizomes rot completely and result in shoot collapse. The affected rhizomes also exhibit a wet, soft decay and emit foul smell. Bacteria gain entry into the plant through wounds and insect injury. The pathogen is gram negative and soil borne in nature.

**Management:** Removal and destruction of crop debris can check the spread. The infected areas on the rhizomes can be removed with the help of knife but knife should be disinfected each time by dipping or whipping it with 70 per cent denatured alcohol. Shallow planting, careful handling is advisable while shady places or poorly drained sites should be avoided. The control of iris borer is also necessary to eliminate the soft rot disease.

**Insects — Aphids:** Three species of aphids infest iris leaves: crescent-marked lily, lily, and melon.

**Management:** Spray with Sevin or malathion (0.2%).

**Tulip Bulb Aphid (Dysaphis tulipae)**

**Symptoms:** This aphid infests bulbous and rhizomatous iris in storage.

**Management:** Before storing, dust the bulbs or rhizomes with Sevin powder. Aphids that latter appear on the foliage can be controlled with malathion sprays.

**Lesser Bulb Fly (Eumerus tuberculatus)**

**Symptoms:** Larvae of this insect infest the bulbs of Japanese iris.

**Management:** This is a difficult pest to control. Since symptoms do not appear until the damage has been done. In areas where this pest is known to be troublesome healthy stocks can be preserved by planting them in shade or by providing them shade with muslin rolls or similar material. Egg laying females can be discouraged by raking or sifting soil over plants to fill the holes that are left as the leaves die down.

**Iris Borer (Macronoctus onusta)**

**Symptoms:** Iris growers find the iris borer perhaps their most destructive insect pest, not only on account of the damage it does directly, but also because it may introduce the bacterium *Erwinia carotovora* which causes the foul-smelling soft rot. The borer pupates in the soil or in the old rhizomes, and emerges as a gray moth about 1 1/4 inches across the wings. The eggs are laid in small clusters on old iris leaves or other debris. When the iris leaves are 5 to 6 inches high, the eggs hatch and the young caterpillars enter the leaves a few inches above the ground. The irregular tunnels which they make as they feed can be seen in the leaves. The full-grown borers are about 1 1/4 inches long, whitish with black heads. Hundreds of them may be found in a small planting, and they may be very destructive to some kinds of iris, such as *Iris tectorum*;
the delta irises seem to be especially susceptible, though the borer may not introduce bacterial rot. In certain seasons, hatching of eggs may be delayed so that the larvae enter the flower buds and cause these to turn brown with a watery rot. The borers then penetrate the flower stalks, still carrying the rot bacteria, so that eventually the stalks also collapse with a wet, foul-smelling rot.

**Management:** Since the insects winter as eggs on old leaves and on debris left on the beds as a protection, such material should be raked up and destroyed. Spraying with one part of 47.5 per cent Thimet diluted in 200 to 400 parts of water can control this pest. Other materials that will control borers are listed under bacterial soft rot, above.

**Florida Red** (*Chrysomphalus aonidum*)

**Symptoms:** This scale frequently occurs on irises grown in greenhouses, especially where species of citrus are also grown. Affected plants are very much disfigured with conspicuous chlorotic spots about the insects, converging into large yellow areas.

**Management:** Spray with malathion or Sevin to control the crawler stage.

**Iris Thrips** (*Irodothrips iridis*)

**Symptoms:** Japanese iris is especially susceptible to thrips. The adults may be seen crawling about between the folds of the leaf bases, sometimes even appearing on the outer surface. The young are at first white and so can be distinguished from the yellow gladiolus thrips. Iris thrips rasp the surface of the inner folds of leaves, making them susceptible to further injury by fungi. The thrips feed from May to November, causing a russetting and soot-like blackening of the foliage and much stunting of growth. The tops usually die out and turn brown and in older clumps almost all of the roots die. The adult lives over winter in close contact with the leaf buds, being protected by the bases of the old leaves.

**Management:** Thrips can be controlled with periodic application of Cygon or malathion sprays. The sprays should be directed down into the leaf bases, for many of the insects feed between the folds of the leaves. Where thrips are abundant, the treatment should be made every 5 to 7 days until the infestation is cleaned up. Gladiolus thrips, tobacco thrips, and rose thrips attack iris at times. Cygon also controls these species or malathion sprays. Treating with Sevin dust as suggested above for the tulip bulb aphid can control thrips and mites carried over on bulbs.

**Verbena Bud Moth** (*Endothenia hebesana*)

**Symptoms:** Small green caterpillars attack the seedpod and feed on its contents. A few days after the egg hatch, the larvae feed on the outside of the plant. At this stage they are very conspicuous. Later they also enter the pod, leaving only a slight scales or depression at the point of entrance. Just before pupating, the larvae make a hole to the outside and pupate when halfway out, the brown case projecting from the black-ringed hole. There are at least four generations during a season. The insect winters as a larva or cocoon on leaves or in seeds. They have been found to do much damage, especially where breeding of irises is carried on.
Management: Spray with Sevin (0.2%). The first application should be made soon after the pods have developed, the second about 8 or 10 days later, and, if necessary, a third application 20 days after the first one.

Iris Weevil (*Mononychus vulpeculus*)

**Symptoms**: This is another insect that attacks iris seeds. It tunnels through the seeds, eating out the embryo and reducing each seed to only a thin ring. At the end of a tunnel, which sometimes extends through a whole row of seeds, the small dark weevil may be found with its flat, disc-shaped body fitting snugly into the last seed it has mutilated. The limited extent of its injury to cultivated plants has not warranted a study of control methods, but, as the adult weevils are flying, applications of a methoxychlor spray early in the season should kill the insect before its eggs are laid and the larvae bore into the pod.

Zebra Caterpillar (*Ceramica picta*)

**Symptoms**: This caterpillar also is a nuisance in iris plantings because of its habit of feeding on the leaves and flower stalks and also on the valuable seedpods.

**Management**: Spraying with Sevin or *Bacillus thuringiensis* will control the young larvae.

Bulb Mite (*Rhizoglyphus echinopus*)

**Symptoms**: This mite may infest bulbous iris in the field and in storage.

**Management**: Discard rotting or soft bulbs containing mites. Soak the remainder for 1 hour in hot water held at 38-40° C.

Stem and Bulb Nematode (*Ditylenchus dipsaci*)

**Symptoms**: This nema first attacks the stem and sheath, then enters bulb. The parasites do not enter the parts above the soil level. Discoloration and streaking at the base of the stem are made visible by scraping off the outer coating.

**Management**: A 3-hour dip in a 1:200 formalin solution at 30°C will provide control.

Nematodes — *De Man’s Meadow Nematode* (*Pratylenchus pratensis*)

**Symptoms**: This species causes root lesions. Infested plants become dwarfed and die out.

**Management**: Formalin sterilization of infested soil or treat with a nematicide.

Southern Root-Knot Nematode (*Meloidogyne incognita*)

This nematode is reported from the roots of rhizomatous iris.

**Management**: Application of carbofuran, phorate 1 g a.i./m. Tagetes also reduces nematode population.
FREESIA

Wilt and corm-rot (*Fusarium oxysporum* Schlecht.)

**Symptoms:** Infected plants become yellow, then gradually wilt, die and collapse. The fungus invades the main roots, the laterals and the feeding rootless, which turn pink and then dark brown on rooting. From these the infection spreads to the corms. The lesions on the corms are deep pink. The tissues of the diseased corms first become yellowish, and as the decay progresses, they turn dark brown. In the advanced stage the vascular bundles turn brown surrounded by a pink discoluration. Ultimately the affected tissues become chalky-white, and the dried corm is a hard, dry, friable mass which crumbles under light pressure. The disease is not common.

**Management:** Use of disease-free soil and healthy planting material, following 3-4 years rotation, and dipping the corms in benomyl or Bavistin (0.1 %) for half an hour before, planting are recommended.

Insects — Lily Aphid (*Neomyzus circumflexus*): The crescent-marked lily aphid may attack greenhouse-grown freesias.

**Management:** Spray with malathion.

Bulb Mite (*Rhizoglyphus echinopus*): This mite may infest freesia corms, causing a soft, mushy decay.

**Management:** Same as in *Tulips*.

Thrips: Same as in *Gladiolus*

Nematodes — *Southern Root-Knot Nematode* (*Meloidogyne incognita*): This nema is occasionally reported as serious in freesia plantings in fields.

**Management:** Sprinkling or flooding with 0.1% nemaphos.

SOLIDAGO (Golden Rod)

Diseases — Fungal

Scab (*Elsinoe solidiginis*)

**Symptoms:** Young plants are killed, or dwarfed and stunted, when attacked by this fungus. Leaves that are attacked by this pathogen becomes covered with a fungal growth that causes them to wither and die as they unfurl. Infected stems become rusty.

**Management:** Remove and destroy the affected leaves.

Rust (*Coleosporium asterum*)

**Symptoms:** The infection takes place at rosette stage.

**Management:** Remove and destroy infected plants/ leaves.
Powdery mildews (*Oidium* spp.)

**Symptoms:** A powdery white coating develops on the leaves, stem, and above ground parts. It is usually seen as discreet off white patches which later on enlarge and cover the plant extensively. The leaves may turn yellow and drop prematurely.

**Management:** Spray of sulfex (0.2 %), benomyl (0.1 %) or dinocap (0.1 %) proves effective.

**Insects — Chrysanthemum Lace Bug (*Corythuca marmorata*):** The insect feeds on the leaves of golden rod and then moves to chrysanthemum and aster.

**Control:** Diazonin, malathion or Sevin (0.2%) sprays control the lace bugs.

**Orange Tartrix (*Argyrotaenia citrina*):** This dirty white, brown-headed caterpillar rolls and webs the leaves on which it feeds.

**Control:** Spray with Diazonin (0.2%) when the caterpillars begin to feed.

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STRETLITZIA (Bird of Paradise)

**Diseases — Fungal**

**Root rot (*Fusarium moniliforme*):** The plant is prone to this pathogen at seedling stage. The rotting starts when there is high humidity. Disease is seed borne.

**Management:** Presoaking the seed in warm water at 35 °C for 30 minutes before sowing can control disease.

**Insects — Mealybugs (*Planococcus citri* and *Psudococcus longispinus*):** The citrus and long tailed mealybugs infest this host

**Control:** Spray with malathion (0.2%).

**Scale (*Hemiberlesia rupus*):** The greedy scale, so common on many other trees, shrubs, trees and herbaceous ornamentals, also infest this ornamental.

**Control:** Spray with malathion or Sevin (0.2%) to control the young crawler.

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CHINA ASTER (*Callistephus chinensis*)

**Disease — Fungal**

**Collar and root rot (*Phytophthora cryptogea*):** This disease is very severe under high moisture conditions in soil. The symptoms are sudden wilting of the plants and rotting of stem at the ground level and root rot. The control measures include avoiding excess moisture by growing on ridges and use of fungicides such as Captan, Mancozeb, Metalaxyl and Fosetyl-A1 (0.2 %).

**Wilt (*Fusarium* spp.)**

**Symptoms:** The symptoms include yellowing of leaves and rotting of collar portions of plants. The control measures are sterilization of soil before planting and application of fungicides such
as benlate or carbendazim. *Sclerotium rolfsii* also causes basal rot and wilt of aster. Radial growth of thick fungal mycelium and buff to dark brown sclerotial bodies are seen at the base of the infected plants.

**Rust** (*Coleosporium solidaginis*)

**Symptoms**: On the lower surface of the leaves bright yellow orange spots appear on young plants.

**Management**: Spray of benlate (0.1%) or calixin (0.1%) was reported to be effective.

**Nematodes** (*Meloidogyne incognita* and *Aphelenchoides ritzema-bosi*)

**Symptoms**: With the infection of nematodes the growth is retarded and leaf become smaller. *Aphelenchoides* species also causes severe leaf disorder.

**Management**: Application of furadan or thimet recommended for the control of nematodes in China aster.

**Viral — Yellows**

**Symptoms**: A serious viral disease in China aster is caused by *Chlorogems callistephi*. The development of pale yellowish tinge on the leaves and a large number of adventitious shoots are the main symptoms. Plants become dwarf and flower discoulouration occurs. The disease is transmitted by a leaf-hopper, *Macrasteles fascifrons*.

**Management**: Control of leafhoppers with suitable insecticide and destruction of diseased plants immediately after the appearance of the symptoms are helpful in minimizing the spread of the disease.

**Insects — Chrysomelid beetle** (*Aulacophora foveicollis*)

**Symptoms**: Beetle attack begins on newly planted crop. Adults cause damage by making holes on leaves and cutting tender shoots resulting in severe defoliation. Grubs feed on roots and underground stems leading to wilting and drying of attacked plants.

**Management**: Deep ploughing exposes grubs, pupae and eggs to natural enemies. Soil application of phorate or carbofuran @ 1.0 kg a.i./ ha controls grubs.

**Semilooper** (*CtenopJusia albostriata*)

**Symptoms**: Caterpillar attacks China aster plants in June. Deep green coloured looper with wavy lines feed extensively on leaves.

**Management**: Spraying of Quinalphos (0.05%) or carbaryl (0.1%) or Chlorpyriphos (0.05%) gives protection against this pest.

**Flower eating caterpillars** (*Helicoverpa armigera* and *Phycita* spp.)

**Symptoms**: Incidence of *H. armigera* occurs in the month of October. Caterpillars feed on flower heads in large numbers destroying flowers. Caterpillars of *Phycita* spp. are green in colour
with brown head. They damage flowers by making groove on the central receptacle and feed on ovaries and stamens of flower heads.

**Stem borer (Platyptilia molopias)**

**Symptoms**: Plume-moth lays white elongate eggs on tips of shoots. Hatched larvae bore into stem and side branches. Cream coloured larvae with black head feed inside shoots resulting in hollowing and wilting of affected shoots.

**Management**: Soil application of carbofuran at 1 kg a.i./ha checks the stem borers.

**Leaf miner (Liriomyza compositell)**

**Symptoms**: Adult fly lays eggs in leaves by puncturing. Pale yellow coloured maggots feed inside leaves and flower calyx by leaving characteristic mines. The affected leaves turn brown and dry in case of severe damage.

**Management**: Physical removal and destruction of affected leaves helps in controlling further damage. Spraying of 0.05% Monocrotophos (or) 0.05% Triazophos (or) 0.05% methyl-o-demeton effectively check the leaf-miner population.

**Leaf Hopper (Macrosteles fascifrons)**

**Symptoms**: The feed on aster plants and help in transmitting the virus.

**Management**: Spray of dimecron (1 ml/l) or rogor (2 ml/l) can effectively control this insect.

**Spider mite (Tetranychus telarius)**

**Symptoms**: Leaves become discoloured and disturbed with the infestation of this insect.

**Management**: To control the pest spraying with Kelthare (2 ml/l) was found effective.

**Jassid (Orosius albicinctus)**

**Symptoms**: Affected plants show chlorosis, upright growth, stunting to many sprouts from axils and transformation of floral organs into leaf like structures.

**Management**: Spray of malathion (0.2%) checks the insect.

**Nematodes — Nematodes (Meloidogyne incognita and Aphelenchoides ritzema-bosí)**

**Symptoms**: With the infection of nematodes the growth is retarded and leaf become smaller. Aphelenchoides species also causes severe leaf disorder.

**Management**: Application of furadan or thimet recommended for the control of nematodes in China aster.
Diseases — Fungal

Leaf Blight (Cercospora jasminicola and Alternaria jasmini): This disease occurs in severe form on Jasminum grandiflorum. Reddish brown circular spots, 2 to 8 mm in diameter are produced on the upper surface of the leaves, spreading rapidly in the rainy season. Affected leaf margins show inward curling and become hard and brittle. In severe cases of infection, vegetative buds and young branches dry up. Since almost all the leaves are affected along with young branches, the plants look unhealthy with appearance of drying up from a distance. The disease appears in the month of May/June and the peak incidence occurs from August to November. Flower production is adversely affected and may cause 50% loss in yield. Varietal screening studies conducted at Tamilnadu Agricultural University, Coimbatore, showed that Jasminum arborescens, J.paniculatum and certain cultivars of J.sambac remained free from leaf blight and J.grandiflorum was highly susceptible to this disease. Jasminum angustifolium, J.auriculatum, J.communis, J.flexile, J.humile, J.pubescens, J.regidum and certain cultivars of J.sambac showed only stray incidence of blight.

Management: Fungicidal trials conducted by using the highly susceptible cultivar of J. grandiflorum revealed that 0.2% Benlate, 0.2% Dithane M-45, 0.1% Bavistin and 1.0% Bordeaux mixture were equally effective to control leaf blight. It was suggested to spray the fungicides at monthly interval commencing from May and continue up to pruning. The number of sprays may vary depending upon the weather conditions and severity of the disease. Spraying of Bordeaux or Copper oxychloride to control the blight is also found effective.

Rust (Uromyces hobsoni)

Symptoms: This disease appear in July-August during monsoon rains, in severe form on J.auriculatum. Other species viz., J.sambac, J.flexile, J.communis and J.angustifolium are also susceptible to rust. The leaves show the presence of orange colouredaecial cups on both sides, but predominantly on the lower surface. Numerous blisters are produced in advanced stages of infection causing yellowing and crinkling of the leaves. The stems and branches are also infected, causing splitting of barks and subsequent death of the branches.

Management: The disease can be controlled by dusting sulphur 20-25 kg/ha. Spraying with Bordeaux or Copper oxychloride was also recommended for the control of rust.

Wilt (Fusarium solani or Sclerotium rolfsii)

Symptoms: This disease is found in J.sambac. The early symptom is yellowing of lower leaves which gradually spreads upwards and finally resulting in death of the plant. In the field, the disease occurs in patches and roots show black colouration. In the case of sclerotial wilt, in addition to the above symptoms, white mycelia are found generally girdling the roots and the sclerotia are found adhering to the roots of the wilted plants.

Management: Drenching the soil around the plants with 1% Bordeaux mixture controls this disease. Jasmines are subject to several other diseases including crown-gall caused by the bacterium Agrobacterium tumefaciens, a blossom blight caused by a species of Phoma and root-
rot caused by *Clitocybe tabescens*.

**Viral — Mosaic**

**Symptoms**: The diseased plants show stunted and yellowish green appearance with small leaves. Yellowish green to chlorotic flecks of 1-2 mm in diameter appear irregularly on the leaf and these streaks form into a ring. The symptoms are more conspicuous on older leaves. The disease is graft-transmissible on *Jasminum simplicifolium* *Jasminum sambac* and *J.pubescens* were found to be highly susceptible to the disease while *J.auriculatum* relatively tolerant.

**Management**: Control of insect vectors will prevent the transmission of the disease.

**Phyllody**

**Symptoms**: This disease is suspected to be caused by mycoplasma. The affected plants produce malformed, reduced greenish flower-like structure instead of fragrant white flowers on panicles, which are highly congested and green in colour. The greenish corolla lobes become reduced and ovate in shape. Flower parts are transformed into leaf-like structures.

**Management**: The disease may be controlled by spraying with tetracycline hydrochloride (250 ppm). Cuttings from infected plants should never be used for planting.

**Insects-Bud Worm, Gallery Worm, Tingid Bug and Scales**

**Symptoms**: *Hendecasis duplifasciatis*, the bud worm which is a greenish larva with a black head bores into immature jasmine buds and feeds on floral structures and in severe cases webbing of buds is also noticed. The gallery worm, *Elasmopalpus jasminophagus* is also a serious pest which causes webbing of terminal leaves, shoots and flowers. The tingid bug, *Coryphauma ayyari* is sometimes noted to be serious. The nymphs and adults suck the sap and cause yellowing of leaves which dry and drop off. Several species of scales infest jasmine.

**Management**: Plants should be sprayed with malathion to control these insects. The occurrence of *Naupinoe geomatralis* can be controlled by the application of a 1:500 of 6% BHC. Spraying during blossoming with 1:4000-6000 solution of 50% diptrex combined with hand picking of larvae and pupae was also recommended.

**Mites**

**Symptoms**: The incidence of red spider mite is high during warm and dry weather, especially during summer. The mites are seen feeding on under surface of the leaves which become yellow and drop off. Severe puckering and discolouration of leaves are caused by gall mite in *J.auriculatum*. The cultivar Parimullai of *J.auriculatum* released from Tamil Nadu Agricultural University, Coimbatore, is resistant to gall mite. The cyclamen mite, *Steneotarsonemus palhdus*, was found to severely damage *J.sambac*.

**Management**: In trials with acaricides, a considerable reduction of infestation followed by 5 applications of Endrin at 10-day interval at 1 g 10% w.p./ 100 gal. Metacid and parathion were less effective and were also phytotoxic. Jasmences are also attacked by *Cacoecia pronubana*. The insecticides recommended for control are phosphonic esters in combination with chlorinated
product. Some of the other pests that have been recorded on jasmine are the green plant hopper (Flata oel/ata), the jasmine bug (Antestiopsis cruoiata) leaf rollers (Glyphodes celsalis) and the blossom midge (Contarinia maculipennia). The eriophyid mite Aceria jasminium can be controlled by granular insecticides carbofuran, phorate and endosulfan at 2 kg a.i./ha. and soil application of Neem cake at 250 and 500 kg/ha. Soil application of 250 kg/ha Neem cake combined either with foliar spray of NSKE at 10% or Neem oil at 3% were all effective in significantly reducing the mite infestation in J.auriculatum.

**Scales**: Twelve species of scales infest jasmine: barnacle, black, Califôrnia red, camphor, chaff, Florida red, green shield, mining, purple, olive, parlatoria, and soft scale.

**Management**: Valuable specimens should be sprayed with Malathion or Sevin to control the crawler stages of these pests.

**Citrus Whitefly (Dialeurodes citri)**: This pest has been reported to infest jasmines.

**Management**: Sprays containing synthetic pyrethroids are very effective against adult whiteflies. Malathion or Cygon sprays will control the nymphal stage of this pest.

**Nematodes**: Infestation of root knot nematode, Meloidogyne incognita in both J.sambac and J.flexile causing small swelling and enlarged rootlets leading to conspicuous pale yellowing of leaves and die back was recorded reported from TNAU, Coimbatore. J.nudiflorum was very susceptible to M.incognita. Application of phormese (4g/plant) during May and September month and pruning in December incorporating 20 kg FYM/plant increased the yield of jasmine by reducing the root knot nematode population by 70% (TNAU, Coimbatore).

**Diseases — Fungal**

**Wilt (Fusarium solani)**

**Symptoms**: The leaves of infected plants become pale and droop. The leaf margins show pinkish brown discolouration and the stem shrivelled. On the root dark lesions are seen which extends upto the collar region. The disease is observed in the field within short time after transplanting in scattered patches and ultimately the plants dry up completely.

**Management**: Application of wet ceresen (0.1%) along with phorate (1 gm/plant) was found effective in checking the disease.

**Alternaria Leaf Spot (Alternaria amaranthi var. crossandrace)**

**Symptoms**: The small circular or irregular yellow spots on the upper surface of the leaves characterize this disease. The spots then enlarge and develop brown concentric rings. Premature droppings of leaves is observed in this disease infected plants.

**Management**: Application of Indofil M-45 (0.3 %) or carbendazim (0.2 %) effectively controls the disease.

**Stem Rot (Rhizoctonia solani)**
Symptom: The disease is characterized by the brown to black lesions on stem just above the soil level resulting in girdling of stem, ultimately the disease extends upto the upper part. Roots also develop rotting in severe infection.

Management: Removal of badly infected plant and fortnightly spray of benomyl (0.2%) and captan (0.25%) of lightly infected plants control the disease.

Root and crown Rot (Phytophthora nicotianae)

Symptom: The disease causes violet discolouration of leaves and foot region of the plants rot. Although there may ultimately be some regrowth from the lateral buds the plants usually die. When cut through, the interior of the crown appears brown and necrotic. The causal fungus is soil inhabiting and infection arises through damaged tissues.

Management: Treatment is very difficult and the best plan is to destroy the affected plants and replace with the fresh stock at a site far from original. To control the disease drenching of Fosetyl - Al (0.2%) is reported to be effective.

Leaf Blight (Collectorichum crossandrae)

Symptoms: With the infection the leaves become brownish and depressed necrotic areas appear. The leaf spot become darker as they expand. Infected leaves ultimately shrivel and drop off, leaving a barren stem with a whorl of young leaves at the top.

Management: Provide adequate ventilation if grown in greenhouses. Remove all plant debris. At the first sign of the symptoms destroy affected parts and spray the plants with a sulphur suspension and repeat at intervals of a week or ten days.

Insects — Scales (Saissetia nigra, S. viridis)

Symptoms: Colonies of nymphs and mature females infest leaves, stems and flowers. All stages feed on sap and most species excrete honeydew, which makes plants sticky and encourages growth of sooty molds. Persistent infestations weaken growth as well as making plants unsightly.

Management: Wiping of scales with a soft rag, sponge can treat greenhouse or potted plants quite effectively, or brush dipped into soapy water. Chemical treatments are only effective when applied to kill young crawlers before they have settled and started to form protective scale. Application of non persistent insecticides like diazinon or malathion @ 0.3-0.6 Kg a.i./ha can easily kill the scale insects.

White Fly (Lipaleyrodes sp.)

Symptoms: Adults, eggs and scales are present on underside of leaves and upper surfaces are often fouled with sticky honeydew and sooty molds. Most of the potted plants, house or greenhouse plants get infested and the continuous infestations reduce plant vigour and sooty molds make infested plants look unsightly. Leaves of some plants develop yellow spots and other discolorations where whiteflies have fed.
**Management**: Prevent serious damage by examining plants regularly. If adult or immature whiteflies are seen, spray thoroughly with an appropriate contact insecticide such as malathion 0.5 l/ha or systemic insecticide like dimethoate 0.4 Kg/ha sprayed weekly controls the insect.

**Nematodes** (*Pratylenchus delaterei, Meloidogyne incognita*)

**Symptoms**: The roots exhibit brown to black lesions and prominent galls. It causes chlorotic leaves which ultimately turned to white at the advanced stage of infestation. With severe attack plants become stunted without any side shoots and remain defoliated.

**Management**: Application of phorate (1 gm/plant) a week after planting checks the lesion nematodes.

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**MARIGOLD**

**Diseases — Fungal**

**Leaf Spot and Bud-Rot** (*Alternaria tagetica* Shome & Mustafee, *A. zinniae* Ellis, *A. alternata* (Fr.) Keissl.)

**Symptoms**: The leaf spots caused are small, blackish brown, circular to irregular and fast spreading. The pathogens develop when atmospheric humidity is high and have also been reported to cause flower and bud rot severe infections and flower blight. Severe infection reduces seed yield, seed viability and flower quality. Seeds from infected flowers had been shown to reproduce 2 to 5 percent diseased seedlings. Infections in general start from lower leaves and progress upwards.

**Management**: For effective management of the disease follow clean cultivation, grow resistant varieties and destroy collateral hosts. Spray the crop with mancozeb (0.2%) or carbendazim (0.05%) with the first appearance of disease and then at ten days intervals.

**Collar and Root rots** (*Rhizoctonia solani* Kuhn, *Sclerotium rolfsii* Sacc., *Pythium ultimum* Trow and *Phytophthora cryptogea* Pethybr. & Luff).

**Symptoms**: The infection takes place near the soil level or in the roots. The roots get completely rotten under warm and humid conditions. Foliage gives wilted appearance and finally entire plant dies. Numerous round, mustard seeds like sclerotia of *Sclerotium rolfsii* around the infected zones are indicative of this pathogen.

**Management**: Disease is managed by growing resistant varieties, avoid overcrowding of plants and following 3 to 4 years crop rotation. Drenching the soil with carbendazim and metalaxyl (0.2 %) reduces the disease incidence.

**Minor diseases**: In addition to these disease other pathogen like *Macrophomina phaseolina* (Tassi) Goid., *Verticillium alboatrum* Reinke & Berthier, *Colesporium pacificum* Cummins, *Fusarium* species and *Botrytis cinerea* pers ex Fr., have been reported on marigold particularly in wet weather causing varying degrees of losses. Bacterial wilt (*Ralstonia solanacearum* Yabuuchi *et al.*) and crown gall (*Agrobacterium tumefaciens* Smith & Townsend) Conn, are the bacterial diseases reported on this crop. Both the pathogens have wide host range and the
suitable crop rotations should be practiced to manage them.

**Viral — Cucumber Mosaic Virus**

**Symptoms**: Produces mottling on the leaves leading to reduction in leaf size and distortion. Infected plants are stunted and produce few low-grade flowers. This disease is transmitted by *Aphis craccivora*.

**Management**: General control measures like destruction of infected plants, spraying of Malathion to control insects.

**Insects — Japanese Beetle (Papilla japonica)**: The African marigold is especially attractive to this insect which feeds on the open blossoms and leaves.

**Tarnished Plant Bug (Ligus lineolaris)**

**Symptoms**: Marigold is one of the ornamentals being attacked by this insect. They often congregate on flowers causing distortion of flowers and leaves.

**Management**: Spray with Cygon or with a mixture of Kelthane and Sevin.

**Leafhoppers (Empoascus fabae and Macrosteles fascifrons)**

**Symptoms**: A characteristic symptom of this pest is a cupping or inrolling of the leaves at the margins, which fold over the midrib and twisting of the petioles. The underside of infested leaves are seen to become purplish red. Complete wilting of branch tips and leaflets has also been observed. New shoots develop below the point of attack. The dwarf varieties are more severely attacked than the taller ones. Delay in flowering occurs due to repeated attack of this insect.

**Management**: Spray of malathion (0.2 %) is found to be effective.

**Greenhouse Leaf Tier (Udea rubigalis)**

**Symptoms**: These caterpillars not only attack greenhouse plants but also the garden on the plants. They tie the leaves or flowers together with a web and feed on the undersides of the leaves.

**Management**: Young plants should be sprayed with Sevin (0.2 %) before webbing occurs.

**NELUMBIO (LOTUS)**

**Diseases — Fungal**

**Alternaria Leaf Spot (Alternaria nelumbii)**

**Symptoms**: Small reddish-brown spots appear, usually bordered with light green. They increase in size. The leaves curl up and die from the margin inward. Another leaf spot that occasionally appears on this host is caused by *Cercospora nelumbonis*.

**Management**: Although no controls have been developed, it is likely that applications of copper or dithiocarbamate sprays will control these leaf spots.
Insects — Aphids *(Rhopalosiphum nymphaeae* and *Aphis gossypii)*.

**Symptoms** : The waterlily and cotton aphids infest *Nelumbo*. Leaves are disfigured and decayed and flowers are discolored. The former species may cause much damage to Japanese cherry trees growing near waterlily ponds. It passes the winter in many kinds of fruit trees.

**Management** : Spray with Meta-Systox, Sevin, or malathion.

Japanese Beetle *(Popillia japonica)*.

**Symptoms** : During July and August the adult beetles may be very destructive. They feed on the leaves and flowers.

**Management** : The beetles can be controlled by spraying 200g Hexavin 50WP in 50 litres of water /acre.

NYMPHAEA (Water Lily)

Diseases — Fungal

Nymphaea leaf Spot *(Ramularia nymphaerum)*

**Symptoms** : Spots on both leaf surfaces are at first rounded with concentric zoning but later enlarge irregularly and change from reddish to grey-brown or black and finally rupture in the center. The mycelium is superficial and forms compact white spots on the lesions.

**Management** : Affected leaves may be removed. Fungicides should not be applied so as to save water from contamination.

Insects — Waterlily aphid *(Rhopalosiphum nymphaeae)*

**Symptoms** : This aphid is one of the destructive pests of waterlilies. Colonies of dark green or brown aphids infest flower buds and leaves of water lilies and some of the other aquatic plants causing distortion and discoloration.

**Management** : Spray the plants as soon as the aphids are detected with only those insecticides which do not infect the fishes and aquatic animals. Use non-persistent insecticides like nicotine or malathion or remove aphids by hosing with water.

Waterlily Leaf Cutter *(Syncita obliteralis)*

**Symptoms** : The brown-marked moth lays its eggs near he edge of the leaf or on the lower surface of the leaf. The grubs are cream coloured with a dark line on the back, the head very small and light brown. They feed for a short time as miners which then make themselves in a protecting case by cutting out lens shaped pieces of leaves and fastening them together with the leaves. This elastic case helps the grub for breathing and keeps the water away. Attacked leaves become very ragged and much rotted. This insect also feeds on other aquatic plants.

Waterlily Leaf Beetle *(Pyrrhalta nymphaeae)*

**Symptoms** : These dark brown beetles feed on the leaves and flowers of water lily. They feed on both sides of leaves that are not submerged.
Management: Insecticides should not be used against this pest if fish are present in the pools. In such circumstances the best method is to knock adults and larvae off leaves with a powerful jet of water from garden hose. Fish will then be able to feed on them in the water and the treatment can be repeated as necessary. If there is no danger to fish, non persistent insecticides, such as nicotine or malathion can be used as dust or sprays.

FICUS ELASTICA (RUBBER-PLANT)

Diseases — Fungal

Anthracnose [Glomerella cingulata (Stonem.) Spauld. & Schrrenk and imperfect state Colletotrichum gloeosporioides Penzig, Gloeosporium fructigenum Berk.]

Symptoms: This disease may appear as tip burn, the ends of the leaves turning at first yellowish, then tan, and finally dark brown. The scorching may extend completely around leaf, working in from the margins until the entire leaf is destroyed. This fungus disease may be clearly distinguished from the scorch and tip burn due to unfavourable growing conditions and from the leaf spots caused by other fungi. It resembles the scorching of plants brought into apartments, where the hot dry air and little ventilation frequently leads to leaf fall of varieties of rubber plant used as house plants. Anthracnose develops pale rose coloured pustules sometimes in zones but usually more or less scattered. Slight wounds by insects, braking of leaves or collection of water on the leaves for considerable period favours infection. Lesions initiate from the tips of leaves and spread inwards, and later coalesce with one another. The lesions are irregular, initially buff-coloured and later on ochraceous with dark brown haloes. The fungus is widespread after the summer season and with the onset of rains. The disease is very destructive.

Management: Avoid syringing the leaves frequently. Pick off and destroy the infected leaves.

Leaf-spot (Phyllosticta ficiola Pat.): Infection spots are buff to ochraceous with reddish-black haloes, starting from any region and spreading further covering large areas and resulting in leaf drying

Leaf-spot (Phomopsis Sacc.): Irregular spots are irregular, greyish-black later turning papery.

Leaf-spot (Diplodia Fr.): Irregular greyish-black spots delimited by thin, brown margins appear. Infected areas fall off.

Management: Pick off and destroy badly infected leaves. Fungicidal sprays are rarely used on this host.

Insects — Mealybug (Pseudococcus longispinus)

Symptoms: These insects collect in great numbers on the bases of the leaves and on the undersides of the leaf-blades; they shed much honeydew, upon which sooty mold is apt to grow and cause still further damage by cutting off the light.

Management: Spray with malathion (0.2 %).

Scales: Twenty-one species of scales may infest this host.
**Management**: Malathion or Sevin sprays applied when the young scales are crawling about are very effective. Repeat the application 10 days after the first.

**Thrips**: Three kinds of thrips affect rubber-plants: banded greenhouse, dracaena, and the greenhouse.

**Management**: Spray with Cygon or malathion (0.2 %) when the thrips are seen.

**Nematodes**: Root Knot (*Meloidogyne incognita* and *M. fici*).

**Symptoms**: The former, known as the root-knot nema, infests the roots of many other plants. The latter, known as the fig nema, is found on nursery-grown *Ficus*.

**Management**: Application of phorate (1.2 kg a.i./ha) is recommended.

**AGLAONEMA**

**Diseases — Fungal**

**Root and Stem Rot** (*Pellicularia filamentosa* and *Pythium splendens*): These two fungi are frequently responsible for a root and stem rot of this host, particularly in the South India.

**Management**: Soak healthy plants in clean or hot water at for 30 minutes then cooled and planted.

**Bacterial — Leaf Spot and Leaf Blight** (*Xanthomonas dieffenbachiae* and *Erwinia carotovora var. aroideae*).

**Symptoms**: *Xanthomonas* causes a leaf spot followed by blight. The latter then enters to cause complete collapse of the leaves.

**Management**: No controls have been developed, but copper fungicides or antibiotics might help to keep this disease under control.

**Soft Rot** (*Erwinia chrysanthemi*): A soft rot of leaves of *Aglaonema pictum* occurs in nurseries.

**Management**: Avoid high humidity.

**Nematodes** (*Pratylenchus musicola*): Eelworms commonly infest the roots of Chinese evergreens in nurseries.

**Control**: A nematicide such as Nemagon is suggested for trial by commercial growers.

**DIEFFENBACHIA**

**Diseases — Fungal**

**Cephalosporium leaf-spot** (*C. dieffenbachiae*)

**Symptoms**: The infection appears first on the young, rolled leaves as tiny, reddish-brown circular to elongate lesions. These increase in size as the leaf unfolds and expands, later
becoming almost circular in outline sharply delimited by dark brown border. The central portion of the lesions becomes greyish. Lesions are also formed on other parts of the plant. The disease is not common.

**Management**: Bavistin (0.1%) or copper oxychloride (0.3%) spray in recommended.

**Stem-rot** (*Phytophthora palmivora* Butler)

**Symptoms**: It appears as small, irregular, water-soaked lesions on the main stem at the soil level. The affected tissues become soft and water and the plant shows yellowing followed by wilting and eventually breaks at the soil level. Internally the invaded tissues are water-soaked and dark grey. The disease is not common.

**Management**: As relatively high temperature (25-28°C), high humidity and poor soil drainage favour the disease, water stagnation should be avoided by regulating watering. Drenching the soil with Bordeaux mixture (1%), and spraying the plants with Bordeaux mixture or Difolatan (0.3%) are helpful.

**Leaf-spot** (*Xanthomonas dieffenbachiae*)

**Symptoms**: Circular, reddish-brown spots, surrounded by light yellow water-soaked margins appear. As the spots enlarge or coalesce, their centres become brown and dry. Often the area between the spots and the leaf margins turns yellow and dies. This disease is not common.

**Management**: Spraying with Pansamycin (50 ppm) or Streptocycline, and roguing out infected plants are recommended. (In Dieffenbachia only fungal and bacterial diseases have been reported. Other pest problems are not very significant).

**DRACAENA**

**Diseases — Fungal**

**Leaf Spot** (*Phyllosticta maculicola*)

**Symptoms**: Plants of any age may show irregular, small, brown spots with yellowish margins. The black fruiting bodies (pycnidia) develop long coils of spores, which may be spread from plant to plant during spray of water in the greenhouse grown plants.

**Management**: Cut off and destroy infected leaves. Avoid wetting the foliage.

**Fusarium Leaf Spot** (*Fusarium moniliforme*)

**Symptoms**: Circular or slightly raised, reddish brown lesions surrounded by a yellow halo are characteristic of this disease.

**Management**: Weekly sprays of mancozeb (0.3%) provides effective control.

**Tip Blight** (*Physalospora dracenae*)

**Symptoms**: The diseased areas become shrunken and straw coloured. The disease begins on the lower leaves, which may be killed while the centre leaves are dead only at the tips.
Management: Same as above in leaf spots.

Insects — Dracaena Thrips (*Heliothrips dracaenae*): Infested plants are marked with small red and brown globules of liquid that are deposited by feeding thrips.

Management: Severe thrips attack the greenhouse or controlled environment grown plants, which sometimes are often associated with poor growing conditions resulting from overwatering or overheating. Regular watering and maintenance of a cooler, more humid conditions can therefore help to prevent infestations. Similarly, infestations on outdoor plants are worst during hot dry periods and thrips populations are reduced in cool, wet weather. Use dimethoate .03% for spraying the plants.

Mealybug (*Pseudococcus longispinus*)

Symptoms: This pest occasionally attacks dracaenas. Mealybug colonies develop on leaves, stems, buds, flowers and other aerial parts of plants. Persistent infestations weaken plants, especially when growing plants are attacked and foul plant surfaces with honeydew and sooty moulds.

Management: To eradicate established infestations first remove as many colonies by cutting out and burning infested shoots and branches, by washing plants with powerful jets of water or by removing mealybugs with a household paint brush. Once the main colonies have been removed than spray the plants with malathion or dimethoate.

**PHILODENDRON**

Diseases — Fungal

Leaf Spot (*Colletotrichum philodendroni* *Pellicularia filamentosa* and *P. rolfsii*)

Symptoms: Small yellow brown spots appear on the upper surfaces of leaves and on the leaf stalks and stem. They often appear first at the stem base but can affect all parts including the foliage. They enlarge rapidly and become oval and 5 cm or more in length.

Management: Commercial growers can control by soaking propagating canes in hot water at 40-42° C, for 30 minutes. The treated canes should be cooled and placed in steamed sphagnum moss until roots or buds appear. They should then be cut into sections of one or two buds and planted in clean soil.

Bacterial: One strain of the bacterium *Erwinia chrysanthemi* causes irregular, water soaked areas on leaves and collapse of petioles in some nurseries. Spraying with Agrimycin can control the disease.

Physiological diseases: Philodendrons as a group can tolerate the unfavourable environment of most apartments and homes better than most house plants. Nevertheless they frequently contract several troubles that are mistaken for parasitic diseases. Yellowing of the lower leaves, failure of the new leaves to attain normal size, and browning and death of the growing tips are usually due to insufficient light. Although these plants do not require direct sun, they need a great deal of indirect light. Another cause for these troubles is an excessively dry atmosphere.
Philodendrons are tropical plants that thrive under high humidity. Among other causes for poor growth of this host are overwatering, improper soil drainage, an excess or lack of plant food, and a pot-bound condition of the roots.

**GREENHOUSE AND HOUSE PLANTS**

The special conditions of the greenhouse or glasshouse and house plants are grown favour diseases and some pests. Some of them are native species that thrive when they are protected from extremes of climate and from predators and parasites that attack them outdoors and some are accidentally being introduced with planting materials. High temperatures and humidities may also encourage the development and spread of diseases and in addition pot grown plants are especially liable to drought, water logging and other disorders. During winter plants may suffer from low temperatures and in summer they may be scorched by strong sun if not adequately shaded (houseplants). General problems of the plants grown in greenhouses and house plants are as follows:

- **Root and Foot rot**: Roots rotten and plants generally unthrifty
- **Leaf Spots**: Leaves variously spotted or malformed
- **Grey Mold**: Leaves and or other parts rotten and bearing fluffy grey mold growth.
- **Powdery Mildew**: Leaves and or other parts with powdery coating.
- **Waterlogging**: Leaves yellowed, sometimes with dry angular blotches and generally stunted, roots may become rotten.
- **Drought**: Leaves generally dull, later wilted and turning browning.
- **Aphids**: Plants infested by small, wingless and winged green yellow, brown, or black insects often in dense colonies on leaves, young shoots, stems, buds, and flowers; plants sticky, often sooty, growth checked and sometimes distorted
- **Whitefly**: Plants infested by small, white, winged insects, especially on undersides of young leaves; plants sticky; sometimes sooty
- **Mealy bugs**: Plants infested by soft bodied, wingless insects covered in white wax powder and filaments, often forming clusters in leaf axils and on stems; plants sticky, sometimes sooty
- **Scale Insects**: Plants infested by brown, yellow or white, flat or raised scales, especially on underside of leaves and also on stem, foliage sticky, sometimes sooty.
- **Spider Mite**: Plants infested by small green or redbrown mites, especially on underside of leaves, fine light flecking on upper surfaces later turn yellow and leaves dry out and die, fine silk webbing may cover affected parts.
- **Leafhoppers**: Plants infested by small winged and wingless yellow green insects feeding on underside of leaves and causing coarse light mottling on upper surfaces; empty moult skins often attached to leaves.
Thrips: Plants infested by narrow-bodied yellow, brown or black wingless and winged insects especially on leaves and in flower buds and flowers; leaves and flowers with fine white flecking and other discoloration.

Management: Good hygiene and careful routine inspection can prevent much trouble. In protected cultivation as practised in India in polyhouses, greenhouses, simple or computerised structures, problems mentioned above occur singly or in combination. For managing root rots or foot rots, it is essential to raise plants in sterilised composts in disinfected pots or in ready prepared bags. Care must be taken to ensure that water supplies such as rain water butts are cleaned regularly. Valuable greenhouse plants can be induced for new roots by packing moist peat around the stem base and applying top dressing. For spot diseases two or three sprays of thiram or benomyl (0.1 %) at fortnightly interval help in preventing the disease. This is recommended only for the fungi induced spots. Powdery mildews can be well controlled by dinocap and by systemic fungicides, triforine, benomyl, thiophanate methyl and carbendazim. Grey mold can be managed by maintaining good ventilation and raise the temperatures in greenhouses; by avoiding overcrowding of plants, damp and shaded conitions for house plants; removal of buds or flowers that have any reason become moribund as they may be easily colonised by the grey mold fungus; carefully remove affected flowers and buds and spray plants with dichlofluanid, benomyl or thiophanate methyl (0.1 %).

Prevent serious damages by examining plants regularly for insect damage. If adult or immature whiteflies are seen immediately use contact or any systemic insecticide. Many different insecticides may be used to control aphids but to be really effective they must be applied before damaging populations have built up. Aphids can be controlled in covered structures by fumigation with nicotine or dichlorvos. Mealybugs are often difficult to control as they tend to live in inaccessible situations on plants and they are well protected from insecticides by their wax coverings. To eradicate established infestations, first remove as many colonies as possible by cutting out and burning infested shoots and branches, by washing plants with powerful jets of water or by removing mealybugs with a household paint brush. This latter treatment becomes effective by dipping the brush in malathion/nicotine, methylated spirit. After removal spray of malathion/dimethoate/formothion. Severe thrips damage occurs due to underwatering and overheating. Regular watering and maintenance of a cooler, more humid atmosphere can therefore helps in reducing the damage. Similarly, infestations on outdoor plants are usually worst during hot and dry weather and thrips are reduced in cool and wet weather. Contact insecticides like Malathion or nicotine should be used as soon as thrips are visible. The simplest way of checking red spider mites in greenhouses is to spray susceptible plants with a fine mist of plain water twice a day. The high humidity reduces mite activity. Red spider mites generally are often severe on plants that are growing under unfavourable conditions or on plants that are ageing and lacking vigour and pot plants growing at high temperature in dry, overcrowded greenhouses. Infested plants should be removed, as they are the source of hibernation of mite population.

GENERAL GUIDELINES FOR PLANT PROTECTION IN ORNAMENTAL PLANTS

- Disease and insect pest management should be country-wide coordinated approach.
- Development of consultancy and diagnostic schemes for identification and effective
management of diseases and pests in flower crops.

- Development of new varieties or screening of existing varieties for resistance of major diseases and pests.
- Cropping system approach to be developed for management of diseases and pests.
- There is need to develop low input protection technologies to be competitive in the world market.
- There is need to develop integrated pest management (IPM) for promotion of ecological and environmental safety.

**Disease Management**

In polyhouses, emphasis should be on integrated methods of control using less toxic and ecofriendly compounds. Importance should be given to biological control as this is effective in controlled conditions. Bioagents like *Tichoderma* should be used for seed treatment, transplanting dip rather using chemicals. Foliar fertilization therapy should be used widely e.g. powdery mildew can be managed by foliar spray of potassium orthophosphate or potassium dihydrogen phosphate. Care should be taken against introduction of new pathogens/pests into the country.

**Insect Pests Management**

IPM for flower crops under protected cultivation in future should aim for including preventive methods like use of insect proof nets (bio-nets), using double doors glasshouses/ greenhouses/ polyhouses, soil sterilization, monitoring and scouting; soft chemicals like IGR, Avermectins, biological agents like fungus, *Verticillium lecari, Baeveria bassiana*; and plant products like neem and pongamia oils. IPM for field grown flower crops in the open should emphasize on use of cheaper and easily available chemicals like traditional insecticides e.g. endosulfan, metacid, rogor with oils; acaricides like kelthane, wet sulphur, nuvacron, cultural methods like catching and burning, deep ploughing, destroying weeds and plant products; and plant products like neem and pongamia oils and kernel extracts, calotropis leaf extracts. Moreover, regular monitoring and scouting is very important to avoid pest build up.

**Nematode Management**

Use of resistant varieties for the control of root knot nematodes. Integrated management of root knot nematodes in ornamental crops using ecofriendly components e.g. oil cakes (neem and pongamia). Enrichment of FYM with *Trichoderma harzianum* for large scale field application. For this purpose mix 1 kg of *T. harzianum* with 10 kg of neem cake in 1 tonne of FYM, thereafter sprinkle water and cover with polythene sheet and allow for 15 days.

**Phytosanitary Requirements in Export and Import of Ornamental Plants**

Quarantine both of exports and imports to be given utmost importance, so that Indian Floriculture is protected from the ingress of exotic pests and to facilitate safe exports. The identification and maintenance of pest free areas and production sites are of critical concern for sustaining growth of floriculture and quality exports. There is also imperative need for strengthening post-quarantine facilities at minor ports.
<table>
<thead>
<tr>
<th>Plant Organ</th>
<th>Symptom</th>
<th>Likely Pathogen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sown seeds</td>
<td>Failure to emerge, Damping-off</td>
<td><em>Fusarium, Rhizoctonia, Phytophthora, some seedborne diseases</em></td>
</tr>
<tr>
<td>Roots (and tubers)</td>
<td>Necrosis of young root tips and fine feeder roots</td>
<td><em>Pythium, Phytophthora</em></td>
</tr>
<tr>
<td></td>
<td>Necrosis of main roots with:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) dark wet rot</td>
<td><em>Phytophthora</em></td>
</tr>
<tr>
<td></td>
<td>b) dark dry rot</td>
<td><em>Ceratocystis</em></td>
</tr>
<tr>
<td></td>
<td>c) dry rot with red or purple tinge</td>
<td><em>Fusarium</em></td>
</tr>
<tr>
<td></td>
<td>d) Ashy grey rot</td>
<td><em>Macrophomina</em></td>
</tr>
<tr>
<td></td>
<td>e) White to brown mycelial sheets or fans</td>
<td><em>Rosellinia, Rhizoctonia, Armillaria</em></td>
</tr>
<tr>
<td></td>
<td>f) Rhizomorphs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>g) Patchy cortical necrosis</td>
<td></td>
</tr>
<tr>
<td>Stems</td>
<td>Necrosis at soil level :</td>
<td>*Fusarium, Phytophthora, bacteria Rhizoctonia, Sclerotium or other Basidiomycete</td>
</tr>
<tr>
<td></td>
<td>a) dark with no obvious mycelium or sclerotia</td>
<td><em>Basidiomycete</em></td>
</tr>
<tr>
<td></td>
<td>b) brown with mycelium or/and sclerotia evident</td>
<td><em>Agrobacterium</em></td>
</tr>
<tr>
<td></td>
<td>Galls at soil level</td>
<td><em>Elsinoe, Sphaceloma</em></td>
</tr>
<tr>
<td></td>
<td>Lesions, pale and scabby</td>
<td><em>Colletotrichum, Phomopsis etc.</em></td>
</tr>
<tr>
<td></td>
<td>Lesions often cankerous or Anthracnose-like with minute dark fruiting bodies</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pustules of yellow, brown or orange spores</td>
<td><em>Rust</em></td>
</tr>
<tr>
<td></td>
<td>Sclerotia or mycelium running along stem or enveloping it</td>
<td><em>'Web blights' Corticium spp.</em></td>
</tr>
<tr>
<td></td>
<td>White powdery surface sporulation</td>
<td><em>Powdery mildew</em></td>
</tr>
<tr>
<td></td>
<td>White downy surface sporulation</td>
<td><em>Downy mildew</em></td>
</tr>
<tr>
<td></td>
<td>Malformation:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) swelling</td>
<td><em>Virus, systemic fungal infection, Virus etc.</em></td>
</tr>
<tr>
<td></td>
<td>b) shortening of internodes (stunting)</td>
<td><em>Fusarium, some viruses, smuts Systemic fungal infection, some bacteria and viruses Fusarium, Vetriculum dahliae</em></td>
</tr>
<tr>
<td></td>
<td>c) elongation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>d) shoot proliferation (witches broom)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Internal discoloration (of vascular tissue)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Die back (without primary necrosis at base of die back)</td>
<td></td>
</tr>
</tbody>
</table>
Table 1. Disease Symptoms and Likely Pathogens (contd...)

<table>
<thead>
<tr>
<th>Plant Organ</th>
<th>Symptom</th>
<th>Likely Pathogen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaves</td>
<td>Powdery sporulation on surface</td>
<td>Powdery mildew</td>
</tr>
<tr>
<td></td>
<td>Downy sporulation on surface</td>
<td>Downy mildew</td>
</tr>
<tr>
<td></td>
<td>Pustules with yellow, orange or brown spores</td>
<td>Rust</td>
</tr>
<tr>
<td></td>
<td>Pale scabs</td>
<td>Elsinoe, Sphaceloma</td>
</tr>
<tr>
<td></td>
<td>Discrete lesions:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) angular, often with chlorotic halo</td>
<td>Bacteria</td>
</tr>
<tr>
<td></td>
<td>b) more or less circular, grey centre, may be zonate</td>
<td>Cercospora, Drechslera, Corynespora, etc.</td>
</tr>
<tr>
<td></td>
<td>(elongated in monocots)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>c) irregular, containing dark fruiting bodies</td>
<td>Phomopsis, Colletotrichum</td>
</tr>
<tr>
<td></td>
<td>d) irregular large, starting at leaf edge with water-soaked margins</td>
<td>Septoria</td>
</tr>
<tr>
<td></td>
<td>e) marginal scorch with chlorosis and wilting</td>
<td>Phytophthora, Peronospora, bacteria</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Secondary symptom of vascular disease, systemic virus infection or root rot</td>
</tr>
<tr>
<td></td>
<td>Malformation:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) stunted, often chlorotic</td>
<td>Virus, vascular infection, some downy mild virus</td>
</tr>
<tr>
<td></td>
<td>b) chlorotic mottling, mosaic, vein banding, etc.</td>
<td>Virus</td>
</tr>
<tr>
<td></td>
<td>c) puckering, curling</td>
<td>Virus, insect damage</td>
</tr>
<tr>
<td></td>
<td>d) twisting, shredding</td>
<td>Downy mildew (Graminaceous)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fusarium moniliforme, insect damage</td>
</tr>
<tr>
<td></td>
<td>Wilting with milky exudate from cut stem below</td>
<td>Vascular bacterial disease</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(e.g. Pseudomonas)</td>
</tr>
<tr>
<td>Fruits</td>
<td>Anthracnose spots which eventually crack open</td>
<td>Colletotrichum, Phomopsis, some bacteria, feeding punctures of Hemipteran insects</td>
</tr>
<tr>
<td></td>
<td>Distorted, often with irregular ripening</td>
<td>Virus, vascular infection</td>
</tr>
<tr>
<td></td>
<td>Scabs on surface (other symptoms as for leaves)</td>
<td>Elsinoe, Sphaceloma</td>
</tr>
<tr>
<td>Seed pods, ears etc.</td>
<td>Sclerotia in ear (ergot)</td>
<td>Claviceps</td>
</tr>
<tr>
<td></td>
<td>Seeds on flower parts converted to dark spore mass</td>
<td>Smut</td>
</tr>
<tr>
<td></td>
<td>Discolouration of glumes, etc.</td>
<td>Fusarium, Septoria, Drechslera</td>
</tr>
<tr>
<td></td>
<td>Virescence (conversion of floral parts of leafy structure)</td>
<td>Fusarium, Septoria, Drechslera</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Virus, downy mildew.</td>
</tr>
<tr>
<td>Product</td>
<td>Antagonist</td>
<td>Country</td>
</tr>
<tr>
<td>---------</td>
<td>------------</td>
<td>-----------</td>
</tr>
<tr>
<td>Contans</td>
<td>Coniothyrium minitans</td>
<td>Germany</td>
</tr>
<tr>
<td>KONI</td>
<td>C. minitans</td>
<td>Hungary</td>
</tr>
<tr>
<td>Biofox C</td>
<td>Fusarium oxysporum</td>
<td>Italy</td>
</tr>
<tr>
<td>Fusaclean</td>
<td>F. oxysporum</td>
<td>France</td>
</tr>
<tr>
<td>Soil Gard</td>
<td>Gliocladium virens</td>
<td>USA</td>
</tr>
<tr>
<td>Primastop</td>
<td>G. catenulatum</td>
<td>Finland</td>
</tr>
<tr>
<td>Polygandron</td>
<td>Pythium oligandrum</td>
<td>Slovak</td>
</tr>
<tr>
<td>Bio-fungus</td>
<td>Trichoderma spp.</td>
<td>Belgium</td>
</tr>
<tr>
<td>Binab-T</td>
<td>T. harzianum, T.polysorum</td>
<td>Sweden,</td>
</tr>
<tr>
<td>Root Shield</td>
<td>T. harzianum</td>
<td>USA</td>
</tr>
<tr>
<td>Supresivit</td>
<td>T. harzianum</td>
<td>Denmark</td>
</tr>
<tr>
<td>T22G, T22</td>
<td>T. harzianum</td>
<td>USA</td>
</tr>
<tr>
<td>Trichodex</td>
<td>T. harzianum</td>
<td>Israel</td>
</tr>
<tr>
<td>MTR-35</td>
<td>Trichoderma spp.</td>
<td>Israel</td>
</tr>
<tr>
<td>Root Pro</td>
<td>Trichoderma</td>
<td>Israel</td>
</tr>
<tr>
<td>Trichoderma 2000</td>
<td>Trichoderma spp.</td>
<td>Israel</td>
</tr>
<tr>
<td>Trichopel, Trichodowels,</td>
<td>T. harzianum, T. viride</td>
<td>Newzealand</td>
</tr>
<tr>
<td>Protoš WG</td>
<td>Talaromyces flavus</td>
<td>Germany</td>
</tr>
<tr>
<td>Product</td>
<td>Bioagent</td>
<td>Developing agency</td>
</tr>
<tr>
<td>-----------------</td>
<td>---------------------------------</td>
<td>--------------------------------------------</td>
</tr>
<tr>
<td><strong>Fungal</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trichogaurd</td>
<td><em>Trichoderma viride</em></td>
<td>Anu Biotech Int. Ltd., Faridabad</td>
</tr>
<tr>
<td>Funginil</td>
<td><em>T. viride</em></td>
<td>Crop Health Bioproduct Research Centre, Gaziabad</td>
</tr>
<tr>
<td>Ecofit</td>
<td><em>T. viride</em></td>
<td>Hoechst and Schering Agr EVO Ltd., Mumbai</td>
</tr>
<tr>
<td>Biderma</td>
<td><em>T. viride</em></td>
<td>Biotech international Ltd., New Delhi</td>
</tr>
<tr>
<td>EcoDerma</td>
<td><em>T. viride + T. harzianum</em></td>
<td>Margo Biocontrol Pvt. Ltd., Bangalore</td>
</tr>
<tr>
<td>Defence-SF</td>
<td><em>T. viride</em></td>
<td>Wockhardt Life Science Ltd., Mumbai</td>
</tr>
<tr>
<td>Tricho-X</td>
<td><em>T. viride</em></td>
<td>Excel Industries Ltd., Mumbai</td>
</tr>
<tr>
<td>Biogaurd</td>
<td><em>T. viride</em></td>
<td>Krishi Rasayan Export Pvt. Ltd., Solan (H.P.)</td>
</tr>
<tr>
<td>Biocon</td>
<td><em>T. viride</em></td>
<td>Tocklai experimental Station, Tea Research Association, Johrat, Assam</td>
</tr>
<tr>
<td>Biocure-F</td>
<td><em>T. viride</em></td>
<td>T. Stanes Company Ltd., Coimbatore</td>
</tr>
<tr>
<td>Kalisena SD</td>
<td><em>Aspergillus niger</em></td>
<td>Cadila Pharmaceuticals Ltd., Ahmedabad</td>
</tr>
<tr>
<td>Kalisena SL</td>
<td>AN-27</td>
<td></td>
</tr>
<tr>
<td><strong>Bacterial</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biotok</td>
<td><em>Bacillus subtilis</em></td>
<td>Tocklai experimental Station, Tea Research Association, Johrat, Assam</td>
</tr>
<tr>
<td>Biocure-B</td>
<td><em>Psedomonas fluorescens</em></td>
<td>T. Stanes Company Ltd., Coimbatore</td>
</tr>
<tr>
<td>Bioshield</td>
<td><em>Psedomonas fluorescens</em></td>
<td>Anu Biotech Int. Ltd., Faridabad</td>
</tr>
<tr>
<td>Common Name</td>
<td>Chemical Name</td>
<td>Commercial formulation</td>
</tr>
<tr>
<td>-------------</td>
<td>---------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>Benodanil</td>
<td>2-iodobenzoic acid anilide</td>
<td>BAS-3170</td>
</tr>
<tr>
<td>Benomyl</td>
<td>Methyl -(butylcarbamoyl)-2-benzimidazole-carbamate</td>
<td>Benlate</td>
</tr>
<tr>
<td>Captafol</td>
<td>Cis-N-(1, 1,2,2-tetrachloro-ethylthio)-4-cyclohexane-1,2-dicarboximide</td>
<td>Difolotan</td>
</tr>
<tr>
<td>Captan</td>
<td>N-(triarylom-ethylthio)-4-cyclohexene-1, 2-dicarboximide</td>
<td>Orthocide</td>
</tr>
<tr>
<td>Carbendazim</td>
<td>Methyl-1-1-benzimidazole-1-yl carbamate</td>
<td>Bavistin, Derosol</td>
</tr>
<tr>
<td>Carboxin</td>
<td>5, 6-dihydro-2-methyl-, 4-oxathiin-3-carboxanilide</td>
<td>Vitavax, DMOC</td>
</tr>
<tr>
<td>Dinocap</td>
<td>A mixture of 2, 4-dinitro-6-octylphenyl crotonate and 2, 6-dinitro-4-octylphenyl crotonate</td>
<td>Karathane</td>
</tr>
<tr>
<td>Ethirimol</td>
<td>5-n-butyl-ethylamino-4-hydroxy-6-methyl-pyrimidine</td>
<td>Milicurb</td>
</tr>
<tr>
<td>Common Name</td>
<td>Chemical Name</td>
<td>Commercial formulation</td>
</tr>
<tr>
<td>-------------</td>
<td>---------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>9) Fe<del>b</del>m</td>
<td>Ferric dimethyl-dithiocarbamate</td>
<td>Hexaferb.</td>
</tr>
<tr>
<td>10) Folpet</td>
<td>N-(trichloromethylthio)</td>
<td>Phaltan</td>
</tr>
<tr>
<td>12) Nabam</td>
<td>Disodium ethylenebisdi-thiocarbamate + some metallic sulphates</td>
<td>Dithane A-40</td>
</tr>
<tr>
<td>13) PCNB or quintozene</td>
<td>Pentachloro-mitrobenzene</td>
<td>Brassicol</td>
</tr>
<tr>
<td>14) Thiobendazole</td>
<td>2-(4-thiazolyl) benzimidazole</td>
<td>Mertect, TBZ</td>
</tr>
<tr>
<td>15) Thiophanate</td>
<td>Diethyl-4, 4'-O-phenylenebis (3-thioallophanate)</td>
<td>Cercobin-M Topsin-M</td>
</tr>
<tr>
<td>16) Tridemorph</td>
<td>N-tridecyl-2, 6-dimethylmorpholine</td>
<td>Calixin</td>
</tr>
<tr>
<td>17) Zineb</td>
<td>Zinc ethylene bisdithiocarbamate</td>
<td>Dithane Z-78</td>
</tr>
<tr>
<td>18) Ziram</td>
<td>Zinc dimethyl dithiocarbamate</td>
<td>Ziride</td>
</tr>
<tr>
<td>S.No.</td>
<td>Name of Insecticide</td>
<td>Doses generally recommended</td>
</tr>
<tr>
<td>-------</td>
<td>---------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>1</td>
<td>Acephate</td>
<td>0.5 kg a.i./ha (granules or dust)</td>
</tr>
<tr>
<td>2</td>
<td>Carbaryl</td>
<td>Use at manufacturer's rate</td>
</tr>
<tr>
<td>3</td>
<td>Carbofuran</td>
<td>0.5 kg a.i./ha (granules applied to the water)</td>
</tr>
<tr>
<td>4</td>
<td>Chlorpyrifos</td>
<td>0.1-0.5 kg a.i./ha</td>
</tr>
<tr>
<td>5</td>
<td>Disulfoton</td>
<td>1.0-1.5 kg a.i./ha (granules at planting)</td>
</tr>
<tr>
<td>6</td>
<td>Endosulfan</td>
<td>0.75-1.0 kg a.i./ha (granule or emulsifiable concentrate)</td>
</tr>
<tr>
<td>7</td>
<td>Fenitrothion</td>
<td>1.0 kg a.i./ha</td>
</tr>
<tr>
<td>8</td>
<td>Fenithion</td>
<td>1.0-1.5 kg a.i./ha (granules)</td>
</tr>
<tr>
<td>9</td>
<td>Malathion</td>
<td>0.5-1.0 kg a.i./ha (ULV, resistance problems widespread)</td>
</tr>
<tr>
<td>10</td>
<td>Phorate</td>
<td>1.2 kg a.i./ha (granules)</td>
</tr>
<tr>
<td>11</td>
<td>Cypermethrin</td>
<td>0.03-0.1 kg a.i./ha (ULV at manufacturer's rates)</td>
</tr>
<tr>
<td>12</td>
<td>Diazinon</td>
<td>0.3-0.6 kg a.i./ha</td>
</tr>
<tr>
<td>13</td>
<td>Dichlorvos</td>
<td>0.25-1.5 kg a.i./ha</td>
</tr>
<tr>
<td>14</td>
<td>Dimethoate</td>
<td>0.4 kg a.i./ha (ULV at manufacturer's rates)</td>
</tr>
<tr>
<td>15</td>
<td>Fenvalerate</td>
<td>150-250g a.i./ha</td>
</tr>
<tr>
<td>16</td>
<td>Formothion</td>
<td>0.3-0.5 L a.i./ha</td>
</tr>
<tr>
<td>17</td>
<td>HCH</td>
<td>(ULV at manufacturer's rates)</td>
</tr>
<tr>
<td>18</td>
<td>Permethrin</td>
<td>(ULV at manufacturer's rates)</td>
</tr>
<tr>
<td>19</td>
<td>Resmethrin</td>
<td>(ULV at manufacturer's rates)</td>
</tr>
<tr>
<td>20</td>
<td>Thiometon</td>
<td>0.5 L a.i./ha</td>
</tr>
<tr>
<td>21</td>
<td>Triazophos</td>
<td>0.4-0.6 kg a.i./ha</td>
</tr>
<tr>
<td>22</td>
<td>Dieldrin</td>
<td>Now seldom used because of resistance, and hazard to natural enemies</td>
</tr>
<tr>
<td>23</td>
<td>Azinphos</td>
<td>500-750g a.i./ha (general rate)</td>
</tr>
<tr>
<td>24</td>
<td>Methidiothion</td>
<td>30-60 g a.i. /100L (Fruits); 250-800g/ha (Field crops)</td>
</tr>
<tr>
<td>25</td>
<td>Propoxur</td>
<td>250-1200g a.i. /ha (According to pcrop and pest)</td>
</tr>
<tr>
<td>26</td>
<td>BTH</td>
<td>0.5-1.0 kg product/ha (Bacillus thuringensis)</td>
</tr>
<tr>
<td>27</td>
<td>Diflubenzuron</td>
<td>1.5-30g a.i/ 100 L water (growth regulator)</td>
</tr>
<tr>
<td>28</td>
<td>Binapalryl</td>
<td>0.4-0.75 kg a.i./ha</td>
</tr>
<tr>
<td>29</td>
<td>Cholobenzilate</td>
<td>0.75-1.0 kg a.i./ha</td>
</tr>
<tr>
<td>30</td>
<td>Cyhexatin</td>
<td>0.4 kg a.i./ha</td>
</tr>
<tr>
<td>31</td>
<td>Dicofol</td>
<td>0.2 kg a.i./ha or ULV at manufacturer's rates</td>
</tr>
<tr>
<td>32</td>
<td>Sulphur</td>
<td>According to manufacturer's recommendations (usually 0.01%)</td>
</tr>
<tr>
<td>Common Name</td>
<td>Trade/Commercial Name</td>
<td>Formulations</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------------------------------------------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>1. CHLORINATED HYDROCARBONS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aldrin I</td>
<td>Aldrin, Alcrop, Aldrex, Aldrin, Kilter, Mildrin, Termalit</td>
<td>5 D, 30 EC, 20EC</td>
</tr>
<tr>
<td>Chlorodane I</td>
<td>Agrosan, Chlorodane, Chloroddra, Mitox, Starchlor, Termex, Termikil, Vegfrichlorbu</td>
<td>5 D, 10 D, 20 EC</td>
</tr>
<tr>
<td>DDTI</td>
<td>950, Agdit, Carox, Corodet, DDT, DEE, Deetol, Entomit, Hildit-Didinex, Intox DDT, Kilpest, Ramdit, Starrdit, SulBit-5 D, Tafarol, Tafeidex TOL, Topdit</td>
<td>18.5 EC</td>
</tr>
<tr>
<td>Dicofol I/A</td>
<td>Banmite, Delcofol, Dicofol, Difol, Hilfol, Kelthane, Micothane, Tagfol, Vikfol</td>
<td>18 EC</td>
</tr>
<tr>
<td>Dieldrin</td>
<td>Dieldrin</td>
<td>18.5 EC</td>
</tr>
<tr>
<td>HCH (BHC) I</td>
<td>Agrobenez, Benzichlor, Corohex, Entemix, Gammamaxene, Hexidol, Hilbech, Intox BHC, KeroBHC, KilpestBHC, Premodole, Ramacholare, Solchlor, Submar, Sulbez-50</td>
<td>10 D, 50 WP</td>
</tr>
<tr>
<td>Heptachlor I</td>
<td>Agrochlor, Heptachlor, Heptaf, Heptar, Heptox, Heptox, Vegfo</td>
<td>2D, 20EC</td>
</tr>
</tbody>
</table>
Table 6. List of Insecticides Commonly Used in Pest Control (contd...)

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Trade/Commercial Name</th>
<th>Formulations</th>
<th>Mode of Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lindane I</td>
<td>Agrodone, Canon, Gamma BHC, Knodane, Lindon, Lindone, Lindane, Lin sulpn, Micodane, Rasayan</td>
<td>6G 20 EC</td>
<td>S,F,G</td>
</tr>
<tr>
<td>Tetradoxon I/A</td>
<td>Agrodifon, Hexamiton, Tedion, Treat</td>
<td>8 EC</td>
<td>C</td>
</tr>
<tr>
<td>Toxaphene I/A</td>
<td>Anatox, Corotox, Hexatox, Toxaphene, Toxaphan</td>
<td>10 D 80 EC</td>
<td>C,S</td>
</tr>
</tbody>
</table>

2. ORGANOPHOSPHATES

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Trade/Commercial Name</th>
<th>Formulations</th>
<th>Mode of Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acephate I</td>
<td>Acemil, Agrophate, Asataf, Orthene, Starthene Lancer</td>
<td>25 EC 75 SP</td>
<td>Sy, S, C</td>
</tr>
<tr>
<td>Carbofuran</td>
<td>Trithion</td>
<td>25 WP, 3 D, 10 G</td>
<td>C</td>
</tr>
<tr>
<td>Chlor-fen-</td>
<td>Birlane</td>
<td>24 EC 10 G</td>
<td>C, C,F</td>
</tr>
<tr>
<td>phos I/N/A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chlor-pyrinphos I</td>
<td>Agrofos, Bangspan, Chlorofos, Coroban, Danusban, Durmet, Durshan, Giphos, Hyban, Lethal, Radar, Ruban, Suban, Subban 20</td>
<td>20 EC</td>
<td>C, S, F</td>
</tr>
<tr>
<td>Diazinon I/N/A</td>
<td>Agrozin, Basudin, Bazanon, Delzinon, Suzinnon, Zionovl</td>
<td>5 G 20 EC</td>
<td>C, S, F</td>
</tr>
<tr>
<td>Dichlorvos I/A</td>
<td>Agrovan-76, Bangvos, Bargros, Dichlorvos, Divipan, Divipan, Divisol, Nukem 776, Nuvan, Nuvasul, Paradeep, Vapona</td>
<td>76 WSC</td>
<td>C, F</td>
</tr>
<tr>
<td>Dimethoate I/A</td>
<td>Agrodiment-30, Agromat, Cifor, Corothiate, Cropgor, Cygon, Hygro, Devigon, Dimor, Dimer, Dimethoate I/A, Dimethoate, Dimex, Entogor, Hexagor, Kemithoate, Kilxdimethoate, Kiltex, Micor, Milgor, Paragor, Parrydimate, Rogor, Sicothate, Sulgor, Tagor, Tara 909, Vikagor</td>
<td>30 EC</td>
<td>Sy, C, F</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Common Name</th>
<th>Trade/Commercial Name</th>
<th>Formulations</th>
<th>Mode of Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disulfoton I/A</td>
<td>Solvirex, Disyston</td>
<td>5 G</td>
<td>Sy, C, S</td>
</tr>
<tr>
<td>Ethion I/A</td>
<td>Demite, Dhanumit, Ethiosul, Fosmite, Fieathion, Force, Fosmite, Mitcil, MIT 505, Novathion, Tafethion, Vegfru fosmite</td>
<td>50 EC</td>
<td>C</td>
</tr>
<tr>
<td>Fenitrothion I/A</td>
<td>Accothion, Agrothion, Fenitox, Fenitrogil-50, Fenitrothion, Fethiol, Folithion, Hexafen, Sumithion</td>
<td>5 D 50 EC</td>
<td>C,S,F</td>
</tr>
<tr>
<td>Fenithion I/A</td>
<td>Lebaycid, Fenithion</td>
<td>100 EC</td>
<td>E, S</td>
</tr>
<tr>
<td>Formothion I/A</td>
<td>Anthio</td>
<td>25 EC</td>
<td>Sy, C,S</td>
</tr>
<tr>
<td>Malathion I</td>
<td>Agrolmal, Agromala, Bangmal, Bugtax, Corothion, Cythion, Entomol, Hilthion, Kathion, Kpmalathion, Malahi-90, Malamar, Malathion, Malatox, Malaohe, Svlmalathion, Taimal</td>
<td>5 D, 25 WDP, 50 EC</td>
<td>C,S</td>
</tr>
<tr>
<td>Menazon I</td>
<td>Sayfos</td>
<td>70 WP</td>
<td>Sy, C, S</td>
</tr>
<tr>
<td>Mephos-folan, I</td>
<td>Cytrolane</td>
<td>5 G</td>
<td>C, Sy</td>
</tr>
<tr>
<td>Methamidophos I/A</td>
<td>Monitor, Metataf, Tamaron</td>
<td>50 EC, 40 WSC, C</td>
<td>Sy</td>
</tr>
<tr>
<td>Methyl-Demeton I/A</td>
<td>Hexastox, Himax, Knockout, Metasystox, Parastox</td>
<td>25 EC</td>
<td>Sy, C, S</td>
</tr>
<tr>
<td>Methyl parathion</td>
<td>Agropara, Agrotex, Corocid, Devithion, Dhanumar, Entocid, FolidoM, Kagrodal, Kexpar, Kildet, Kilex, Klofos, Luthion, Milon, Metacid, metapar, Methylpara thion, Metpar-780, M.Devithion, Paracrop, Parahit, Paramar, Paramet, Parasul, Parafaf, Parathol, Paratok, Rampidd, Ramthion, Tagpar, Vegtro, Vika cid, 2 D, 50 EC, 46.7 EC</td>
<td>C,S,F</td>
<td></td>
</tr>
<tr>
<td>Monocrotophos</td>
<td>Azodrin, Agrocron, Agromohare, Balwan, Corophos, Croton, Entofos, Glorephos, Hileron, Hycrophos, Kagrophos,</td>
<td>70 WP</td>
<td>Sy, C, S</td>
</tr>
</tbody>
</table>
Table 6. List of Insecticides Commonly Used in Pest Control (contd...)

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Trade/Commercial Name</th>
<th>Formulations</th>
<th>Mode of Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mephos-folan, l</td>
<td>Cytrolane</td>
<td>5G</td>
<td>C, Sy</td>
</tr>
<tr>
<td>Methamidophos I/A</td>
<td>Monitor, Metataf, Tamaron</td>
<td>50 EC, 40 WSC</td>
<td>Sy</td>
</tr>
<tr>
<td>Methyl-demethon I/A</td>
<td>Hexasystox, Himax, Knockout, Metasystox, Parastystox</td>
<td>25 EC</td>
<td>Sy, C, S</td>
</tr>
<tr>
<td>Methyl parathion</td>
<td>Agopara, Agrotex, Corocid, Devithion, Dhanumar, Entocid, FolidolM, Kagrodal, Kempar, Kildet, Kilex, Klofos, Luthion, Milon, Metacid, metapar, Methylparathion, Mephar-760, M.Devithion, Paracrop, Parahit, Paramar, Parame, Parasul, Parataf, Parathol, Paratox, Ramcidd, Ramthion, Tagpar, Vegfrog, Vika cid</td>
<td>2D, 50 EC</td>
<td>C, S, F</td>
</tr>
<tr>
<td>Monocrotophos</td>
<td>Azodrin, Agrocron, Agromohare, Ballan, Corophos, Croton, Entofos, Glophos, Hildron, Hycrophos, Kagrophols, Kileximonocrotophos, Luhlols, Macrophols, Micophos, Milphos, Mondhit, Monocid, Monocil, Monocron, Monocroto, Monogil, Monos—, Monosil, Monostar, Monostar, Nuvarcon, paracron, Parryfos, Phoskill, Ramphos, Rasayanaphos, Sicocil, Triphos, Vegfrogadett, Vimonfos</td>
<td>36WSC, 36 SL</td>
<td>Sy, C</td>
</tr>
<tr>
<td>Phenthoate I/A</td>
<td>Agrophenn, Aimsan, Cilphenthoate, Delsan, Dusab, Elsan, Ferthoate, Phendal, Phenthusal, Phentox, Tugsan</td>
<td>2D, 50 EC</td>
<td>C, F</td>
</tr>
<tr>
<td>Phorate I/N/A</td>
<td>Aelmet, Agrophorate, Cilphtoate, Dragnel, Forate-10G, Foratox, Fortan, Fortox, Glorate, Granutex, Grenade</td>
<td>10 G</td>
<td>Sy, C</td>
</tr>
<tr>
<td>Common Name</td>
<td>Trade/Commercial Name</td>
<td>Formulations</td>
<td>Mode of Action</td>
</tr>
<tr>
<td>-------------</td>
<td>-----------------------</td>
<td>--------------</td>
<td>----------------</td>
</tr>
<tr>
<td>Kamet, Luphate, Milate, Phorate, Starphos-10 G, Starphos, Thimet, Vegfro, Volphor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phosalone I/A</td>
<td>Agrosalone, Micozons, Phosal, Phosalone, Sugalone, Zolone</td>
<td>4 D, 36 EC</td>
<td>S, C</td>
</tr>
<tr>
<td>Profenofos I</td>
<td>Curacron</td>
<td>50 EC</td>
<td>S, C</td>
</tr>
<tr>
<td>Propetamphos I</td>
<td>Safrotin</td>
<td>20 EC</td>
<td>S, C</td>
</tr>
<tr>
<td>Phosphamidon I/A</td>
<td>Agromidon, Agrophos, Bangdon, Cildon, Daron, Dimecron, Entocron, Kilro don, Phamidon, Phoskil, Sicomidon, Sudon, Sumidon, Vimidon</td>
<td>85 WSC</td>
<td>Sy, C, F</td>
</tr>
<tr>
<td>Quinalphos I</td>
<td>Agriphos, Agroquin, Agroquinal, Award, Desalux, Ekalux, Entolux, Gilquin, Hyquin, Keterphos, Kilex Quinalphos, Kinalux, Milux, Pharulux, Quinal, Quinalphos, Quinaltaf, Quinotox, Ramlux, Sicophos, Sicophosa, Solux, Starbrand, Tagquin</td>
<td>1.5 D, 25 EC</td>
<td>C, S</td>
</tr>
<tr>
<td>Thiometon I/A</td>
<td>Ekatin, Hexatin, Thiotox</td>
<td>25 EC</td>
<td>Sy, C, S</td>
</tr>
<tr>
<td>Triazophos I/A</td>
<td>Hostathion</td>
<td>25 EC</td>
<td>S, C</td>
</tr>
<tr>
<td>Trichlorfon I</td>
<td>Dipterex, Trichlorfon, Tugon</td>
<td>5 D, 5 EC, 50 WDP</td>
<td>S, C</td>
</tr>
<tr>
<td>Vamidothion I</td>
<td>Kilval, Vamidothion, Valoson</td>
<td>40 EC</td>
<td>S</td>
</tr>
</tbody>
</table>

3. CARBAMATES

| Aldicarb I/N/A | Temik (Production stopped) | 10 G | Sy, C |
| Carbofuran I/N/A | Furadan, Hexafuran, vegfrediafuran | 3G | Sy, C, S |
| Carbaryl I | Agrovin, Agroyl, Bangwin, Carbamate, Carbaryl, Carvint, Corovin, Devicarb, Hexavin, Kervin, Kildiry, Kilexcarbaryl, Sevidol, Sevimol, Sevin | 5 D, 10 D, 50, 80, 85 WDP 85 S, 40 LV, 4 G | C |

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### Table 6. List of Insecticides Commonly Used in Pest Control (contd...)

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Trade/Commercial Name</th>
<th>Formulations</th>
<th>Mode of Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methomyl I/N</td>
<td>Dunet Lannate</td>
<td>90 WP</td>
<td>C, Sy, S</td>
</tr>
<tr>
<td>Oxamyl I/N</td>
<td>Vydate</td>
<td>24 WSC, 10 G</td>
<td>Sy, C</td>
</tr>
<tr>
<td>Propoxur</td>
<td>Baygon</td>
<td>20 EC, (PH)</td>
<td>C</td>
</tr>
</tbody>
</table>

### 4. PYRETHROIDS

| Cyper- Methrin I | Agrocyper, Bilcyp, Bullet, Challenger, Cilcord, Cymbush, Cymet, Cymetd, Cyper 10, Cyperhit, Cyperkill, Cypermil, Cypersul, Cyporin, Hilcyperin, Hipower, Hycyper, Mortal, Parathrin, Ralothrin, Ramagper, Ripcord, Shakti Ustod, Sicorin, Sirex, Starcyprin, Superkiller, Tackle, Ustaad, Vegfrocolt | 10 EC, 25 EC | C, S |
| Deltamethrin | Decis, Decamethrin, Decathrin | 2.8 EC | S, C |
| Fenvalerate I/A | Agrofen, Bangfenn, Capvalerate, Fenkil, Fenval, Fencid, Fenicidin, Fenhit, Fenis, Fenoron, Fenrio, Gilten, Hitten, Hyfen, Kagrogen, Lufen, Milfen, Parafen, Pavsha fen, Pensil, Ramfen, Sicofen, Starfen, Sujafen, Sumicidin, Tagfen, Trifen, Triumpeeard, Valour, Vegfro, Vikafen | 20 EC | C, S |
| Fluvalinate I/A | Mavrik | | |
| Pyrethrin I | Pyrocome E | | C |
| Alphacyper Methrin I | Alphaguard Fastac | | |
| Aluminium phosphide I/R/A | Al-phos, Celphos, Phostoxin, Quickphos, | 3 g tablet, 56% (F) Capsules | F |
| Bromadiolone R | Bromadiolone, Bromadiolone R | 0.25 SP, SL 0.005 CAKE, 0.005 bait | Anticoagulant |
Table 6. List of Insecticides Commonly Used in Pest Control (contd...)

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Trade/Commercial Name</th>
<th>Formulations</th>
<th>Mode of Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diflubenzuron IGR</td>
<td>Dimilin</td>
<td>25 WP</td>
<td>C,S</td>
</tr>
<tr>
<td>Sulphur I/A/F</td>
<td>Sulphotox, Wetsulf, Devisulfan, Hexsasul, Sulfex, Wetsul</td>
<td>40, 80, 85 WP</td>
<td>C</td>
</tr>
<tr>
<td>Alphacypermethrin I</td>
<td>Alphaguard Fastac</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5. MISCELLANEOUS COMPOUNDS

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Trade/Commercial Name</th>
<th>Formulations</th>
<th>Mode of Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminium phosphide I/R/A</td>
<td>Al-phos, Celphos, Phostoxin, Quickphos</td>
<td>3 g tablet, 56% (F) Capsules</td>
<td></td>
</tr>
<tr>
<td>Bromadiolone R bait</td>
<td>Bromadiolone, Bromadiolone R Anticoagulant</td>
<td>0.25 SP, SL 0.005 CAKE, 0.005</td>
<td></td>
</tr>
<tr>
<td>Diflubenzuron IGR</td>
<td>Dimilin</td>
<td>25 WP</td>
<td>C,S</td>
</tr>
<tr>
<td>Sulphur I/A/F</td>
<td>Sulphotox, Wetsulf, Devisulfan, Hexsasul, Sulfex, Wetsul</td>
<td>40, 80, 85 WP</td>
<td>C</td>
</tr>
<tr>
<td>Warfarin, R</td>
<td>Warfarin, Rotafrin, Rotaflin, Ragumin</td>
<td>0.5 SP</td>
<td>Anticoagulant</td>
</tr>
<tr>
<td>Zinc Phosphide R</td>
<td>Zinc phosphide, Zhinctox, Ratol, Agrospheos</td>
<td>50 WP Granules</td>
<td>F</td>
</tr>
</tbody>
</table>

6. NEEM PRODUCTS

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Trade/Commercial Name</th>
<th>Formulations</th>
<th>Mode of Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neem oil</td>
<td>Godrej Achook, Biosol, Kemissal, Margocide OK, Margosal, Neem plus, Neemguard, Nimbecidine</td>
<td>EC IK</td>
<td>Antifeed ant, Repellent, Oviposition deterrent, IGR</td>
</tr>
<tr>
<td>Neem kernal</td>
<td>Ecomak, Margocide-OK, Neemax, Neemicide</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Oil Based emulsion contains 0.03% and neem kernal based emulsion contains 0.15% azadirachtin.
### Table 6. List of Insecticides Commonly Used in Pest Control (contd...)

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Trade/Commercial Name</th>
<th>Formulations</th>
<th>Mode of Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. BIOCIDET</td>
<td>Delfin (Serotype 3 A&amp; B), Biolep (BTK-I), Bioasp (BTKII), Biobit, Biotex (BTT), Dipel 8L</td>
<td>A-Acaricide, C-Contact poison, F-Fumigant, S-Stomach poison, Sy-Systemic poison; I-Insecticide; IGR-Insect growth regulator; N-Nematicide; R-Rodenticide D-Dust; EC-Emulsifiable Concentrate; G-Granules; LV-Low Volume; SL-Soluble Liquid; SP-Soluble Powder; WDP-Water Dispersible Powder; WG-Water dispersible granules; WP-Wettable Powder; WSC-Water Soluble Concentrate.</td>
<td>Fenthion 100 w/v but 80 EC w/w.</td>
</tr>
</tbody>
</table>

**Note:** LD₅₀ values are for rats unless specified.

Table 6. List of Insecticides Commonly Used in Pest Control (contd...)

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Trade/Commercial Name</th>
<th>Formulations</th>
<th>Mode of Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kamet, Luphate, Milate, Phorate, Starphos-10 G, Starphos, Thimet, Vegfro, Volphor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phosalone I/A</td>
<td>Agrosalone, Micozons, Phosal, Phosalone, Sugalone, Zalone</td>
<td>4 D, 36 EC</td>
<td>S, C</td>
</tr>
<tr>
<td>Profenofos I</td>
<td>Curacron</td>
<td>50 EC</td>
<td>S, C</td>
</tr>
<tr>
<td>Propetamphos I</td>
<td>Sahrotin</td>
<td>20 EC</td>
<td>S, C</td>
</tr>
<tr>
<td>Phosphamidon I/A</td>
<td>Agromidon, Agrophos, Bangdon, Cildon, Daron, Dimecron, Entocron, Kilro don, Phamidon, Phoskil, Sicomidon, Sudon, Sumidon, Vimidon</td>
<td>85 WSC</td>
<td>Sy, C, F</td>
</tr>
<tr>
<td>Quinalphos I</td>
<td>Agriphos, Agroquin, Agroquinal, Award, Desalux, Ekalux, Entolux, Gil quin, Hyquin, Keterphos, Kilex Quinalphos, Kinalux, Milux, Pharulux, Quinal, Quinalphos, Quinaltaf, Quinozox, Ramlux, Sicophos, Sicophosa, Solux, Starbrand, Tagquin</td>
<td>1.5 D, 25 EC</td>
<td>C, S</td>
</tr>
<tr>
<td>Thiometon I/A</td>
<td>Ekatin, Hexatin, Thioctox</td>
<td>25 EC</td>
<td>Sy, C, S</td>
</tr>
<tr>
<td>Triazophos I/A</td>
<td>Hostathion</td>
<td>25 EC</td>
<td>S, C</td>
</tr>
<tr>
<td>Trichlorfon I</td>
<td>Dipterex, Trichlorfon, Tugon</td>
<td>5 D, 5 EC, 50 WDP</td>
<td>S, C</td>
</tr>
<tr>
<td>Vamidothion I</td>
<td>Kilval, Vamidothion, Valoson</td>
<td>40 EC</td>
<td>S</td>
</tr>
</tbody>
</table>

3. CARBAMATES

<table>
<thead>
<tr>
<th>Aldicarb I/N/A</th>
<th>Temik (Production stopped)</th>
<th>10 G</th>
<th>Sy, C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbaryl I</td>
<td>Agrovin, Agroyl, Bangwin, Carbamate, Carbaryl, Carvint, Corvin, Devicarb, Hexavin, Kervin, Kildyril, Kilexcarbaryl, Sevidol, Sevimol, Sevin</td>
<td>5 D, 10 D, 50, 80, 85 WDP 85 S, 40 LV, 4 G</td>
<td>C, S</td>
</tr>
<tr>
<td>Carbofuran, I/N/A</td>
<td>Furadan, Hexafuran, vegfrofiafurant</td>
<td>3G</td>
<td>Sy, C, S</td>
</tr>
</tbody>
</table>

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### Table 6. List of Insecticides Commonly Used in Pest Control (contd...)

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Trade/Commercial Name</th>
<th>Formulations</th>
<th>Mode of Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methomyl l/N</td>
<td>Dunet Lannate</td>
<td>90 WP</td>
<td>C, Sy, S</td>
</tr>
<tr>
<td>Oxamyl l/N</td>
<td>Vydate</td>
<td>24 WSC, 10 G</td>
<td>Sy, C</td>
</tr>
<tr>
<td>Propoxur</td>
<td>Baygon</td>
<td>20 EC, (PH)</td>
<td>C</td>
</tr>
</tbody>
</table>

#### 4. PYRETHROIDS

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Trade/Commercial Name</th>
<th>Formulations</th>
<th>Mode of Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyper- Methrin 1</td>
<td>Agrocyper, Bilcyp, Bullet, Challenger, Cilcord, Cymbush, Cymet, Cymelid, Cyper 10, Cyperhit, Cyperkill, Cypermil, Cypersul, Cyporin, Hilcyperin, Hipower, Hycyper, Mortal, Parathrin, Ralothrin, Ramagper, Ripcord, Shakti Ustod, Sicorin, Sirex, Starcyprin, Superkiller, Tackle, Ustaad, Vegfrocolt</td>
<td>10 EC, 25 EC</td>
<td>C, S</td>
</tr>
<tr>
<td>Deltamethrin</td>
<td>Decis, Decamethrin, Decathrin</td>
<td>2.8 EC</td>
<td>S, C</td>
</tr>
<tr>
<td>Fenvalerate l/A</td>
<td>Agrofen, Bangfenn, Capvalerate, Fenkil, Fenval, Fencid, Fenicidin, Fenhit, Fenis, Fenoron, Fenrio, Gilten, Hitten, Hyfen, Kagrogen, Lufen, Milfen, Parafen, Pavsha fen, Pensil, Ramfen, Sicofen, Starfen, Sujafen, Sumicidin, Tagfen, Trifen, Triumphheard, Valour, Vegfro, Vikafen</td>
<td>20 EC</td>
<td>C, S</td>
</tr>
<tr>
<td>Fluvalinate l/A</td>
<td>Mavrik</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pyrethrin l</td>
<td>Pyrocome E</td>
<td></td>
<td>C</td>
</tr>
<tr>
<td>Alphacyper Methrin 1</td>
<td>Alphaguard Fastac</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aluminium phosphide l/R/A</td>
<td>Al-phos, Celphos, Phostoxin, Quickphos,</td>
<td>3 g tablet, 56% (F) Capsules</td>
<td>F</td>
</tr>
<tr>
<td>Bromadiolone R</td>
<td>Bromadiolone, Bromadiolone R</td>
<td>0.25 SP, SL 0.005 CAKE, 0.005 bait</td>
<td>Anticoagulant</td>
</tr>
</tbody>
</table>
Table 6. List of Insecticides Commonly Used in Pest Control (contd...)

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Trade/Commercial Name</th>
<th>Formulations</th>
<th>Mode of Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diflubenzuron IGR</td>
<td>Dimilin</td>
<td>25 WP</td>
<td>C,S</td>
</tr>
<tr>
<td>Sulphur I/A/F</td>
<td>Sulphotox, Wetsulf, Devisulfan, Hexasul, Sulfex, Wetsul</td>
<td>40, 80, 85 WP</td>
<td>C</td>
</tr>
<tr>
<td>Alphacypermethrin I</td>
<td>Alphaguard Fastac</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5. MISCELLANEOUS COMPOUNDS

<table>
<thead>
<tr>
<th>Aluminium phosphide I/R/A</th>
<th>Al-phos, Celphos, Phostoxin, Quickphos</th>
<th>3 g tablet</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bromadiolone R bait</td>
<td>Bromadiolone, Bromadiolone R Anticoagulant</td>
<td>0.25 SP, SL 0.005 CAKE, 0.005</td>
<td></td>
</tr>
<tr>
<td>Diflubenzuron IGR</td>
<td>Dimilin</td>
<td>25 WP</td>
<td>C,S</td>
</tr>
<tr>
<td>Sulphur I/A/F</td>
<td>Sulphotox, Wetsulf, Devisulfan, Hexasul, Sulfex, Wetsul</td>
<td>40, 80, 85 WP</td>
<td>C</td>
</tr>
<tr>
<td>Warfarin, R</td>
<td>Warfarin, Rotafrin, Rotafrin, Ragumin</td>
<td>0.5 SP</td>
<td>Anticoagulant</td>
</tr>
<tr>
<td>Zinc Phosphide R</td>
<td>Zinc phosphide, Zinctox, Ratol, Agrosphos</td>
<td>50 WP</td>
<td>F</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Granules</td>
<td></td>
</tr>
</tbody>
</table>

6. NEEM PRODUCTS

| Neem oil                | Godrej Achook, Biosol, Kemissal, Margocide OK, Margosal, Neem plus, Neemguard, Nimbecidine | EC IK | Antifeed ant, Repellent, Oviposition deterrent, IGR |
|-------------------------|-----------------------------------------------------------------------------------------|       |                                                      |
| Neem kernal             | Ecomak, Margocide-OK, Neemax, Neemicide                                                 |       |                                                      |

Note: Oil Based emulsion contains 0.03% and neem kernal based emulsion contains 0.15% azadirachtin.
<table>
<thead>
<tr>
<th>Name</th>
<th>Commercial Name</th>
<th>Formulations</th>
<th>Mode of Action</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>7. BIocide</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Bacillus thuringiensis var.</em></td>
<td>Delfin (Serotype 3 A &amp; B), Biolep (BTK-I), Bioasp (BTKII), Biobit, Biotex (BTT), Dipel 8L</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>kurstaki (B.t.k)</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>or <em>thuringiensis</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>(B.t.t)</em></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A-Acaricide, C-Contact poison, F-Fumigant, S-Stomach poison, Sy-Systemic poison; I-Insecticide; IGR-Insect growth regulator; N-Nematicide; R-Rodenticide D-Dust; EC-Emulsifiable Concentrate; G-Granules; LV-Low Volume; SL-Soluble Liquid; SP-Soluble Powder; WDP-Water Dispersible Powder; WG-Water dispersible granules; WP-Wettable Powder; WSC-Water Soluble Concentrate.

Fenthion 100 w/v but 80 EC w/w.

**Note:** LD 50 values are for rats unless specified.
